

BUILDING 707/707A DECOMMISSIONING BASIS FOR INTERIM OPERATION (DBIO)

CHAPTER 6 ACCIDENT ANALYSIS

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6. ACCIDENT ANALYSIS

This chapter presents the methodology and results of the accident analyses for the *Building 707 Decommissioning Basis for Interim Operation (DBIO)* activities. The spectrum of accidents evaluated range from low consequence accidents that are anticipated to occur during the lifetime of the facility to accidents with possibly lower frequencies and greater consequences. By identifying high consequence as well as high frequency accidents, the hazards and accident analyses provide essential risk management information to facility management.

The postulated spectrum of accidents was grouped by type (i.e., fire, explosion, loss of confinement/containment, inadvertent nuclear criticality, External Events (EEs), and natural phenomena). A range of accidents within each type was selected to represent not only the risk-dominant accident, but also other accidents that may require unique controls to ensure adequate protection against the occurrence of the accident and/or its potential consequences. From the spectrum of accidents selected within each accident type, a set of operational controls was derived, thereby establishing the technical basis for Technical Safety Requirements (TSRs), the safety functions of structures, systems, and components (SSCs), and administrative and programmatic controls.

The basic methodology applied to the Building 707 DBIO analyses, regarding the Worker and the Public, relies on the *Building 707 Preliminary Hazards Analysis* (PHA) (Ref. 6-1), as described in Chapter 5. The *Site Preliminary Hazards Analysis* (Ref. 6-2) addresses the Immediate Worker and the role of the Safety Management Programs in protecting the Immediate Worker under both, operational and accident situations.

The accident analysis process uses the results of the PHA to further analyze the scenarios of concern in a more formal, quantitative approach consistent with the methods described in the *Safety Analysis and Risk Assessment Handbook* (SARAH) (Ref. 6-3). The application of the hazards and accident analysis methodologies ultimately produces a set of risk-dominant, or otherwise unique, accident scenarios. Accident scenarios that were evaluated to have unique control requirements were included in the set of selected accidents, regardless of whether they were considered bounding or risk-dominant. The methodologies also identify the controls needed to maintain the potential effects or consequences of the selected accidents to the Public,

Workers, and environment within established DOE evaluation guidelines (as specified in DOE-STD-3011-94, *Guidance for Preparation of DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans*, (Ref. 6-4) and modified by DOE-RFFO (Ref. 6-18).

6.1 ACCIDENT ANALYSIS METHODOLOGY

Hazards, as defined in SARAH, are any source of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to personnel or damage to the facility or the environment. Accidents, also defined in SARAH, are events or sequences of events that involve these hazard sources.

The methodologies described in the following sections were used to perform the following:

- Identify possible accident scenarios that could result from the activities and involve the identified hazards.
- Determine the risk levels and classifications of the postulated scenarios.
- Analyze the postulated accident scenarios and their associated risk levels to select a representative set of bounding, risk-dominant, or otherwise significant scenarios that will encompass all identified DBIO activities and hazards.
- Group the selected representative accident scenarios to facilitate control set selection.
- Develop the analytical basis for deriving a set of controls to effectively manage the identified facility hazards and postulated events, and to establish and maintain a safety envelope for facility operations.

6.1.1 Scenario Selection

The PHA identified eight dominant accidents that required further evaluation (refer to Table 6.1.5-1 of this chapter). In order to analyze the dominant accidents in more depth, additional organization (or sorting) was required. Events were first sorted by event categories. The major event categories are operational accidents (caused by facility conditions or operations), External Events (caused by activities outside the facility that may or may not be related to facility operations), and natural phenomena hazard events (acts of nature). Operational accidents were further subdivided into fires, spills (loss of confinement/containment), explosions, and criticality.

Bounding events within categories were identified and less significant events grouped under them.

6.1.2 Frequency Evaluation

The frequency of each postulated accident event/scenario was estimated qualitatively, without consideration or credit for preventive controls. To assist in making the frequency estimations, failure rate data specified in SARAH, historical event data, engineering judgment, DOE-STD-3009-94, *Preparation Guide for U. S. DOE Nonreactor Nuclear Facility Safety Analysis Reports* (Ref. 6-5), and other sources of information were used as appropriate. For natural phenomena events, frequency of occurrence was based on guidance and information found in References 6-6 through 6-10.

DOE-STD-3011-94, *Guidance for Preparation of DOE 5480.22 (TSR) and DOE 5480.23 (SAR) Implementation Plans* (Ref. 6-4) provides guidance for frequency determination within BIOs. In accordance with this standard, events more frequent than $1.0\text{E-}2/\text{yr}$ are called *ANTICIPATED*, those between $1.0\text{E-}4$ and $1.0\text{E-}2/\text{yr}$ are called *UNLIKELY*, and those less frequent than $1.0\text{E-}4/\text{yr}$ are deemed *EXTREMELY UNLIKELY*. Summary descriptions of these three frequency classes are comparable to those delineated in DOE-STD-3009-94 (Ref. 6-5), and are presented in Table 6.1.1-1.

TABLE 6.1.1-1. QUALITATIVE FREQUENCY CLASSIFICATION

FREQUENCY CLASS NOMENCLATURE	ESTIMATED ANNUAL LIKELIHOOD OF OCCURRENCE	FREQUENCY CLASS DESCRIPTION
<i>ANTICIPATED</i>	$f > 1.0\text{E-}2$	Incidents that may occur several times during the lifetime of the facility.
<i>UNLIKELY</i>	$1.0\text{E-}2 \geq f \geq 1.0\text{E-}4$	Accidents that are not anticipated to occur during the lifetime of the facility. Natural phenomena such as a Uniform Building Code (UBC) –level earthquake, 100-year flood, maximum wind gusts, and so forth are included in this class.
<i>EXTREMELY UNLIKELY</i>	$f < 1.0\text{E-}4$	Accidents that will probably not occur during the life cycle of the facility. This includes design basis accidents.

As previously stated, frequency estimates were primarily qualitatively derived. Therefore, to ensure appropriate conservatism in the estimates, where sufficient qualitative arguments for lower frequencies could not be made for a specific event, the event was classified as *ANTICIPATED*.

6.1.3 Consequence Evaluation

For the hazard analysis, chemical and radiological consequences were calculated for each of the potential receptors/populations of concern, as specified by SARAH and in accordance with DOE guidance:

- Public – Per SARAH, the shortest possible distance from the center of Building 707 to the Site boundary for non-lofted plumes is 1,925 m. For lofted plumes, a distance of 1,925 m for small fires, 3,950 m for medium fires, and 4,200 m for large fires was used.
- Worker – SARAH suggests using 100 m for this receptor.
- Immediate Worker – This refers to the worker who could be located immediately adjacent to the release location or anywhere within the Building 707 Complex.
- With respect to addressing the environment as a receptor, any control set developed to protect the Public and the Worker will also provide a degree of protection to environmental receptors from postulated accidental releases. In addition, protection of the environment is ensured in daily operations by implementation of the safety management programs (SMPs) for *Environmental Management*, *Emergency Preparedness*, and *Waste Management*.

For determining numerical values for consequences in a hazards analysis, DOE-STD-3009-94 (Ref. 6-5) states that the use of complex models or computer codes is considered unnecessary and inappropriate. In fact, the standard suggests the use of "back-of-the-envelope" calculations as acceptable. However, numeric radiological dose consequence values were calculated using the *Radiological Dose Template* (RADIDOSE, Ref. 6-11), details of which are described in SARAH. These values were used in determining radiological consequence to the Public and the Worker for the Building 707 Complex postulated accidents. Consequence levels are correlated to doses according to the values in the matrix shown in Table 6.1.1-2. These values are based on guidance provided by DOE-RFFO (Ref. 6-18).

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TABLE 6.1.1-2. RADIOLOGICAL EVENT CONSEQUENCE LEVELS

CONSEQUENCE LEVEL	PUBLIC DOSE (REM @ 1,925 M)	WORKER DOSE (REM @ 100 M)	IMMEDIATE WORKER DOSE
HIGH	> 5	> 25	Prompt Death
MODERATE	> 0.5	> 5	Serious Injury
LOW	< 0.5	< 5	< Serious Injury

6.1.4 Risk Classification

Once the frequency classes and consequence levels were determined for each accident scenario, the combined frequency classes/consequence levels were tabulated in a risk matrix, as illustrated in Table 6.1.1-3. The completed matrix was then used to prioritize the accident scenarios as a general guideline to determine the acceptability of risk and to select those accident scenarios requiring further analysis. As shown in the table, this DBIO classified each accident scenario, as defined in DOE-STD-3011-94, as *CLASS I (major)*, *CLASS II (serious)*, *CLASS III (marginal)*, or *CLASS IV (negligible)* risks. Per DOE-STD-3011-94 evaluation guidelines, the risk associated with a *CLASS III* or *CLASS IV* scenario does not require additional controls, although further mitigation may be specified as defense-in-depth. Accidents resulting in *CLASS I* or *CLASS II* risk were evaluated to determine if any preventive or mitigative features exist that would reduce the risk to *CLASS III* or *CLASS IV*. The specifically credited (**bolded** within the scenario discussion in the *Control Set* and *defense-in-depth* subsections) and defense-in-depth features were then noted for development of the control set in the TSRs.

TABLE 6.1.1-3. RISK CLASSIFICATION

CONSEQUENCE	FREQUENCY OF OCCURRENCE (PER YEAR)		
	EXTREMELY UNLIKELY < 1.0E-4	UNLIKELY ≥ 1.0E-4 TO ≤ 1.0E-2	ANTICIPATED > 1.0E-2
High	II	I	I
Moderate	III	II	I
Low	IV	III	III

For scenarios that are *CLASS I* or *CLASS II* risk, and where no additional preventive or mitigative controls were identified to reduce the risk to *CLASS III* or *CLASS IV*, controls that reduce the risk (but do not necessarily change the risk to *CLASS III* or *CLASS IV*) were identified for inclusion in the TSRs. For these scenarios, the risk class is stated as part of a risk communication process to ensure that the DOE is cognizant of facility risks through approval of this DBIO.

6.1.5 Selection of Controls

The accident analyses only address those dominant accident scenarios carried forward from the PHA hazards evaluation. The accident analysis process (depicted in Figure 6-1) used to further evaluate and screen those scenarios is summarized here.

The results of the PHA were documented in PHA Table 6.0-1 in terms of "dominant" accident scenarios, which included those scenarios resulting in *CLASS I* or *CLASS II* risk, as well as other scenarios of concern (e.g., because of unique initial conditions or progression or significant consequences to the Worker). The accidents from the PHA that were *CLASS I* or *CLASS II* risk are identified in Table 6.1.5-1.

TABLE 6.1.5-1. SUMMARY OF PHA HAZARDS EVALUATION AND DOMINANT ACCIDENT SELECTION

RISK-DOMINANT SCENARIO PRESENTED IN ACCIDENT ANALYSES	PHA EVENT/ SCENARIO IDENTIFIER
<i>FIRES</i>	
Small Fire – Small Fire in Building	707-D&D-1
Medium Fire – Medium Container Fire	707-D&D-3
Large Fire – Large Fire in Building	707-D&D-5
Major Fire – Major Pool Fire	707-D&D-7A
<i>SPIILLS (LOSS OF CONTAINMENT/CONFINEMENT)</i>	
Spill – Container Spill Inside Building	707-6-13
<i>EXPLOSIONS</i>	
Explosion – Module Vapor-Cloud	707-D&D-9
<i>CRITICALITIES</i>	
Criticality – Oil Moderated Metal	707-D&D-13
<i>NATURAL PHENOMENA AND EXTERNAL EVENTS</i>	
Natural Phenomena – Earthquake	707-6-54

Detailed analyses were performed for the dominant accident scenarios by first evaluating an unmitigated/unprevented condition in which no credit was taken for existing engineered safety features (ESFs) or Administrative Controls (ACs). The analyses of unmitigated scenarios were carried forward from the PHA. For accidents with unacceptably high risk, appropriate controls were applied (i.e., mitigative and/or preventive) to reduce the risk. From this analysis, the appropriate reductions in frequency or consequence, and thus the risk category, were determined.

As illustrated in Figure 6-1, the scenario selection and development process underwent several iterations during document preparation and review to ensure the selection of a complete spectrum of accidents suitable for defining facility-level controls. The selection process included the following key elements:

- Completeness. Beginning with the PHA and continuing through the preparation and review process, the analysts sought out hazards or candidate scenarios that may have been overlooked. These were examined, and the analyzed scenarios were updated, when appropriate, to ensure that a broad spectrum of events was represented in the accident analysis.
- Simplification. Variations on the same scenario (e.g., small fires in different locations from various activities) were combined into generalized scenarios as long as the resulting controls were the same. The resulting analyses are more compact and avoid the incorporation of distinctions that are insignificant to safe building management.
- Control Orientation. Variations on the same scenario were included when they had clear implications for facility level controls [e.g., fires with and without suppression or ventilation, HEPA filtration coverage]. Such implications affect both the adequacy of the control set and the communication of significant considerations for safe building management.

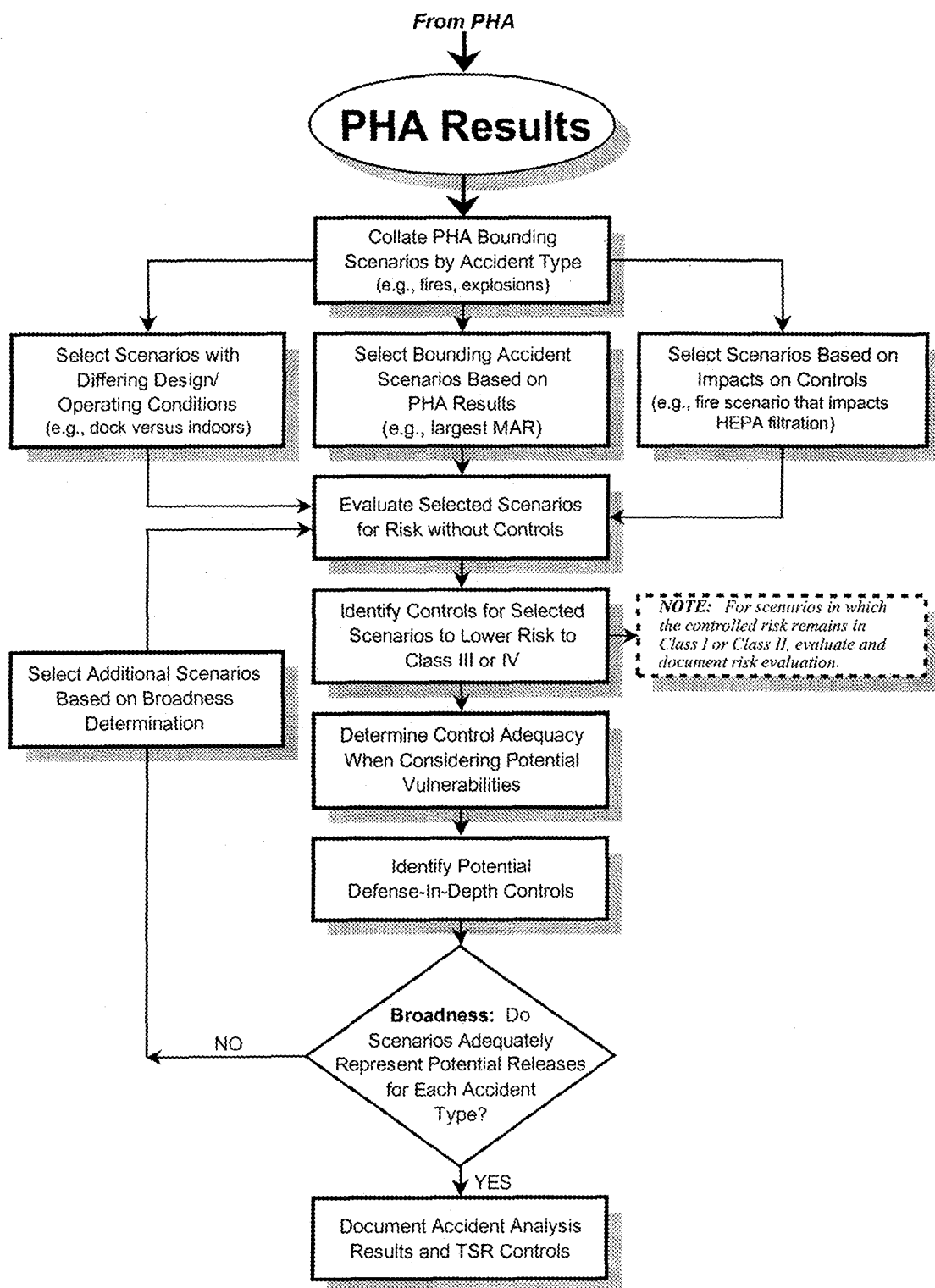


FIGURE 6-1. ACCIDENT ANALYSIS METHODOLOGY SIMPLIFIED FLOW DIAGRAM

Throughout the selection and development process, preventive and mitigative SSCs, and pertinent elements of programmatic controls were identified. This process established functional requirements for SSCs. Chapter 2 of this DBIO provides a summary description of facility systems and components that may be safety-related SSCs. Functional criteria are provided in the representative Technical Safety Requirement (TSR) section. The information obtained through the hazards evaluation identified controls required to protect the Public and the Worker, and provides overall defense-in-depth.

Similarly, numerous controls are generically acknowledged to enhance safety. These controls are protected through the Safety Management Programs (SMPs). These generically credited controls address broader elements of the safety foundation that cannot be practically derived on a scenario-specific basis. They are generally administered on a Site level, then implemented accordingly for individual facilities. The SMPs for the Building 707 Complex are presented in Chapter 3 of this DBIO.

- **Control Set Identification/Selection** provides the engineered and/or administrative controls specifically credited with reducing the risk (i.e., frequency and consequence) of the analyzed accident scenarios determined to be Risk *CLASS I* or *CLASS II*. The method of control set selection to reduce risk (i.e., Risk *CLASS III* or *CLASS IV*) is based on the guidance provided by DOE-RFFO (Ref. 6-18). These specifically credited preventive and mitigative engineered design features (DFs) and ACs define the safe operating parameters for the facility and its operations, and are further specified in the TSRs. A graded approach was used commensurate with the facility closure mission as described below.

Preventive controls are selected to reduce frequency. Mitigative controls are selected to reduce consequences. The following describes the control set identification/selection process:

- ♦ The methodology described in DOE-STD-3009-94, Appendix A (as modified by DOE-RFFO (Ref. 6-18)), was utilized to identify Safety Class SSCs. Safety Class SSCs are those required to reduce the Public dose to less than 5.0 rem.
- ♦ For each accident, SSCs required to achieve Risk *CLASS III* or *CLASS IV* for the Public and/or the Worker were designated as Safety Significant. A goal was set for two additional defense-in-depth controls for each scenario after application of credited systems and programs to complete the Safety Significant control set.

- ◆ Identify any available and viable passive (preferred) or active engineered control(s) that could help to prevent the accident, thereby reducing the frequency and, concurrently, the risk of the scenario. If the engineered control(s) identified to reduce frequency are insufficient to reduce the risk of the scenario (i.e., Risk *CLASS III* or *CLASS IV*), additional controls must be identified.
- ◆ Identify any available and viable ACs that could help to prevent the accident, thereby reducing the frequency and, concurrently, the risk of the scenario (i.e., Risk *CLASS III* or *CLASS IV*). If the control(s) identified to reduce frequency are insufficient to reduce the risk of the scenario (i.e., Risk *CLASS III* or *CLASS IV*), additional controls must be identified.
- ◆ Identify any available and viable passive (preferred) or active engineered control(s) that could help to mitigate the effects of the accident, thereby reducing the consequence and, concurrently, the risk of the scenario (i.e., Risk *CLASS III* or *CLASS IV*). If the control(s) identified to reduce frequency and the engineered control(s) identified to reduce consequence are insufficient to reduce the risk of the scenario (i.e., Risk *CLASS III* or *CLASS IV*), additional controls must be identified.
- ◆ Identify any available and viable ACs that could reduce the consequences of the event and, concurrently, the risk of the scenario (i.e., Risk *CLASS III* or *CLASS IV*).
- ◆ Identify the controls with the highest reliability.
- ◆ Identify the controls closest to the hazard.

In addition to the above guidance, the following additional principles are also applied during the control set identification/selection process:

- ◆ The control set identification/selection process is applied first to the Public and then to the Worker. Because the risk to each of the potential receptors may be different, different controls may be required to reduce that risk. That is, controls selected for the Public are not necessarily credited for the Worker (and vice versa).

- ♦ Preventive controls identified for any receptor are applicable to all receptors, because the frequency of an accident is the same regardless of the potential receptors. However, because the receptors are evaluated in sequence (i.e., first the Public and then the Worker), some preventive control(s) may not be identified immediately. Most commonly, this is because the risk to the Public, without crediting any controls (e.g., a *LOW* consequence without crediting any controls for the Public), results in an unmitigated *CLASS III* risk. In such instances, the controls identified for the Worker are not applied to the Public. However, controls credited for the Worker are considered defense-in-depth controls for the Public.
- ♦ Mitigative controls are identified and selected as applicable to each receptor individually for the accident of concern, and are not necessarily duplicated as credited or defense-in-depth control(s) for the other receptors. It is acknowledged that any mitigative control credited for a given receptor results in a reduced consequence to all receptors.
- ♦ Selected-engineered controls, with surveillance requirements, and proceduralized human actions (i.e., ACs) are credited in the scenario in accordance with SARAH guidelines. ACs are assumed to reduce scenario frequency by a factor of 10 (i.e., 1E-1); engineered controls with surveillance requirements, by a factor of 100 (i.e., 1E-2). These safety features credited to reduce risk provide a basis for developing TSRs for building activities, as well as establishing the safety functions of SSCs and administrative and programmatic controls.
- ♦ Scenarios, which are Class III and Class IV, risk categories without controls are not assigned credited controls. Nevertheless, additional controls providing further risk reduction are specified where practical as defense-in-depth. Defense-in-depth controls are also identified as described above. Although not specifically credited, defense-in-depth controls are also included in the TSRs.

The detailed analyses take credit for the identified controls in one of two ways: (1) the controls are assumed to function as intended, thereby reducing the consequence; or (2) the probability of the controls failing concurrent with an accident is further credited as a reduction in frequency. Either approach constitutes "credit" for the control; therefore, a safety SSC or TSR designation is required. Those safety features that are credited to reduce risk provide a basis for the development of TSRs; the credited applications establish the safety functions of SSCs and administrative and programmatic controls.

In the analysis, certain DFs are generically credited as an assumed initial condition. Credited DFs include passive elements of the facility structure that provide the passive confinement boundary (e.g., walls, floors, and ceilings) and primary containment boundaries (e.g., storage drums and other Pu material packages). Generic crediting of these important passive features is determined (based on engineering judgment) to protect initial assumptions and to focus on consideration of additional required controls. For instance, the passive confinement boundary is a prerequisite for forced ventilation through HEPA filters. Material packaging affords a passive primary boundary that serves both to reduce the frequency of releases and to mitigate releases that may occur (i.e., packaging affects applicable airborne respirable release fractions). Both of these generically credited passive DFs are included as required DFs in the TSRs.

For some of the accidents, assumed initial conditions were built into the scenario development (e.g., OSHA work requirements that are designed to protect Immediate Worker safety). Scenario-specific assumptions were also made, as identified within each accident scenario subsection. Additional assumptions were also generically applied as outlined in Section 6.2 below.

6.2 ACCIDENT ANALYSIS

The analysis of the hazards carried forward from the PHA (and summarized in Chapter 5) is documented in this chapter of the DBIO. Bounding or otherwise unique scenarios were selected from the following PHA operational accident categories or types:

<u>PHA ACCIDENT CATEGORY</u>	<u>ACCIDENT ANALYSIS CATEGORY</u>
FIRES	<i>FIRES</i>
LOSS OF CONTAINMENT/CONFINEMENT	<i>SPILL</i>
DEFLAGRATION OR EXPLOSION	<i>EXPLOSION</i>
CRITICALITY (Inadvertent Nuclear Criticality)	<i>CRITICALITY</i> (Inadvertent Nuclear Criticality)

The selected bounding scenarios were generally those with the largest Material At Risk (MAR) and/or those that resulted in the greatest consequence or potential risk. The specific details of the analysis are provided in CALC-707-01.1081-SWF (Ref. 6-12).

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A sufficient number of events were identified to ensure that the selected bounding scenarios addressed a spectrum of high-frequency/low-consequence and low-frequency/high-consequence events. In addition, analyses of similar scenarios in differing locations were performed to account for differences in operational configuration (e.g., not all areas are equipped with HEPA filtration) or material form.

The spectrum of scenarios encompassed by each bounding accident provides an adequate basis from which to evaluate the risk from different initiators and to identify appropriate controls. Deactivation and Decommissioning (D&D) scenarios were evaluated with MAR based on waste container or material holdup information. As the facility moved from Transition to Closure, the MAR in the facility was reduced to the point where the Material Access Area (MAA) and Protected Area (PA) have been closed. Radiological holdup measurements provided the data which forms the basis of the MAR involved in many of the accidents analyzed.

MODELING ASSUMPTIONS

1. The Public, or maximum offsite individual (MOI), is assumed to be located at 1,925 meters from the accident location for Building 707, and at 1,980 meters for Building 778, according to SARAH (Ref. 6-3). It is noted that there is a new wildlife preserve located closer than 1,925 meters; however, the Site's Emergency Plans have provisions to protect members of the Public entering the area.
2. The Worker is assumed to be located 100 meters from the accident location for calculation purposes. DOE-STD-3011-94 (Ref. 6-4) suggests (but does not require) using 600 meters. However, SARAH recommends using 100 meters, since the Site is relatively compact. Use of the shorter distance is conservative, since it yields higher consequence predictions.
3. The dispersion factor for the Worker and the Public is based on meteorological conditions and release duration. The predominantly used meteorological condition in the analysis is the 95th percentile condition which represents realistic worst-case weather conditions and corresponds to low wind conditions that minimize plume dispersion resulting in a conservative maximum dose to the receptor. The predominantly used release durations are 10, 15, 30, and 60 minutes with the shorter release durations yielding the most conservative results.
4. The dose conversion factors are based on the values in ICRP-68. These have been incorporated as options in RADIDOSE Version 1.4 (Ref. 6-11). Previously, the dose conversion factors were based on ICRP-30. The correlation is that ICRP-68 "Fast" is

analogous to ICRP-30 "D", ICRP-68 "Moderate" is analogous to ICRP-30 "W", and ICRP-68 "Slow" is analogous to ICRP-30 "Y." Within each ICRP-68 definition, there is a further distinction between dose conversion factors for cases that credit HEPA filtration and for cases that do not credit HEPA filtration. The distinction is made to account for the probability that filters will capture larger particles while smaller particles may still pass through.

5. The specific dose conversion factors are a function of the material form (e.g., aged WG Pu) and the solubility class. The dose conversion factors chosen for modeling are specified in the scenario discussions provided in the appendices of the calculation (Ref. 6-12). With the exception of radioactive metals, oxide powders, and surface contamination, which are classified as ICRP-68 "Slow", other materials are classified as ICRP-68 "Moderate" (Solubility Class W using ICRP-30). This includes Transuranic (TRU) waste.
6. The building ambient leakpath factor (LPF) provides an estimate of the amount of material that could leave a building if forced ventilation was unavailable. For scenarios inside Building 707/707A that do not credit active HEPA filtration and which do not result in structural damage to the building, an LPF of 0.1 is assumed to be available.
7. The breathing rate (BR) for heavy activity (i.e., $3.6\text{E-}4 \text{ m}^3/\text{sec.}$) is used for all cases to ensure conservative maximum dose values. The heavy activity BR was derived from RADIDOSE (Ref. 6-11) and is representative of a BR associated with continuous running. For the Worker, the types of activities performed may require significant exertion (e.g., running) to comply with the emergency response procedures. On the other hand, the Public will probably be performing activities requiring less exertion. Therefore, the use of the heavy BR for the Public is conservative.
8. The MAR values cited in this calculation are all in terms of equivalent grams of aged weapons-grade (WG) Pu oxide, unless otherwise noted. The cited values incorporate factors that account for potential inventories of americium (Am). MAR is developed conservatively with the expectation that there will be some uncertainty in actual measured values. Holdup values, that are measured, currently involve the largest uncertainties. Due to previous duct remediation and Deactivation activities, MAR for recovered dispersible plutonium powders is assumed to be one kilogram per 8801 can temporarily stored in gloveboxes or two kilograms per 10-gallon drum instead of reliance on CSOLs.
9. Radiological waste stored on the grounds outside of Buildings 707/707A and 778 is analyzed by the Site SAR.
10. Unless otherwise specified, the accidents are not postulated to result in collateral damage.

- R4-02 | 11. Passive-design confinement structures (e.g., buildings) were implicitly credited to maintain contained configurations of the materials. Drums were also credited as providing a passive confinement function so those scenarios occurring within drums were modeled as "confined" materials. Building structural integrity was also credited, as appropriate, to establish the appropriate leak path factors or to bound the estimated damage caused by the scenario being evaluated. The Building 707 Fire Hazards Analysis (Ref. 6-13) states that the exterior walls are credited with at least a 90-minute fire rating, so the fire scenarios are conservatively modeled as a non-lofted plume because the plume will still be confined within the building.
- R4-02 | 12. In the majority of cases, the default parameters for the airborne release fraction (ARF) and respirable fraction (RF), specified by RADIDOSE (Ref. 6-11), are selected unless otherwise directed by information in SARAH or DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities* (Ref. 6-14).
13. In some cases, the consequence evaluation could not be directly performed because the material involved was in different forms. For instance, an accident could involve surface contamination as well as powdered material. The ARF and RF are dependent not only on the form of the material but also the release mechanism (e.g., explosion, spill, and so forth). In these cases, separate evaluations are conducted using the appropriate DR, ARF, and RF; with the total dose being the sum of the individual doses.

CONTROL SET SELECTION ASSUMPTIONS

1. The Zone I and Zone II ventilation systems are equipped with four and two stages of HEPA filters, respectively. Of these, one stage is credited in the accident analysis. The HEPA filters are tested to demonstrate a 99.9% filtration efficiency. However, for most of the analyses, only a 90% dose reduction factor is credited. Discussion within each of the analyzed scenarios will address the credited efficiency.
2. Historically, two zones of filtration have been specifically identified and credited in the accident analysis. Zone I/IA filtration covers inner confinements, such as gloveboxes and hoods and their associated glovebox exhaust ventilation plenums, and provides contamination control for the immediate worker. Zone II ventilation covers occupied areas in the building and has historically been credited as confinement for accident mitigation. Decommissioning activities that remove gloveboxes and hoods will leave Zone I/IA ventilation systems exposed to occupied areas such that they provide additional ventilation/filtration to Zone II systems. Therefore, neither zone of filtration is specifically credited with accident mitigation in the DBIO. Any forced ventilation system must be filtered and can provide the credited safety function.

3. In accidents where an Immediate Worker is present, the Immediate Worker is assumed to evacuate in an emergency response to the event; to notify others in the vicinity that may inadvertently or otherwise enter the affected area; and to notify the Fire Department through use of the fire phone, or standard phone, as appropriate. The Worker is assumed to evacuate affected areas based on notification by others, the Life Safety/Disaster Warning System (LS/DW), and/or Continuous Air Monitors/Selective Alpha Air Monitors (CAMs)/SAAMs or other alarms, as applicable.
4. SMPs provide Immediate Worker controls and guidelines, via management and maintenance of the programs, governed by Site programs and documents.
5. Operators and maintenance personnel are properly trained to conduct authorized activities (e.g., training in proper inspection methods, emergency response, and so forth).
6. Work activities are conducted in accordance with the Radiation Protection Program and Radiological Work Permit (RWP) requirements for PPE (personal protective equipment), particularly where a Worker has a high probability of direct radiological contamination (e.g., drum opening activities).
7. Immediate Workers are properly trained in work control and conduct of operations procedures and in emergency responses to accident conditions.
8. Immediate Workers observe work control and conduct of operations procedures (e.g., handling and packaging procedures).
9. Facility MAR continues to decrease as the facility is in full Closure activities.

In addition to the assumptions listed above, Table 6.2-1 lists the Building 707/707A MAR and the Building 778 MAR values used. MAR is developed for each specific accident scenario, based on the building MAR as appropriate. Accident specific MAR is developed in the PHA and presented in the accident specific descriptions that follow.

TABLE 6.2-1. SPECIFIC ASSUMPTIONS APPLIED TO MAR ESTIMATES

TYPE	PU EQUIVALENT	BASIS
Building 707/707A	68 kg	The sum of the current dispersible inventories for Buildings 707/707A is based on <ul style="list-style-type: none"> • 1 kg exposed oxide • 14 kg contained TRU • 53 kg holdup (8.4 kg of Pu metal in lathes, 13.4 kg loose surface contamination, and 31.2 kg fixed surface contamination)
Building 778	4.2 kg	200 g holdup 4 kg contained TRU in Components in-transit

The remainder of this section contains subsections for each of the four operational accident categories listed in the beginning of Section 6.2 and the EE/natural phenomena that could impact Building 707. Within each category subsection are additional subsections—one for each dominant accident scenario within the subject category. For each dominant accident scenario presented, a paragraph of the *Scenario Description, Activities, Assumptions, and Material at Risk (MAR)* is provided to set up the scenario. Within the discussions, the *Accident Frequency* and *Accident Consequences and Risk* paragraphs present the estimated frequency, consequences, and risk, with no credit for preventive or mitigative controls other than initial assumption, (e.g., worker training). Risk reduction, based on credited preventive and mitigative controls, is discussed in the *Control Set* paragraph. The credited controls are **bolded** within the scenario discussion in the *Control Set* and *defense-in-depth* subsections. The *Broadness* discussion identifies other scenarios that are encompassed by the scenario under consideration. The summary table for each scenario discussion also presents the frequency, consequence, and risk class (with and without controls), and identifies the preventive and mitigative controls being credited, as well as additional defense-in-depth controls where applicable.

6.2.1 Fires

The hazard analysis process identified numerous fire scenarios involving radioactive materials. This subsection presents analyses of four different scenarios that address fires of varying severity at differing locations or in differing activities within the Building 707 Complex. As discussed in SARAH, there are four fire severity levels: Small, Medium, Large, and Major. The primary discriminators used in differentiating the fires as evaluated for Building 707 were fire duration/size, MAR, consequence, and type of release (e.g., filtered or unfiltered). The following four fire scenarios were modeled, evaluated, and determined bounding for Building 707:

6.2.1.1 SMALL FIRE -- CONTAINER (707-D&D-1)

6.2.1.2 MEDIUM FIRE -- GLOVEBOX (707-D&D-3)

6.2.1.3 LARGE FIRE -- CONTAINER (707-D&D-5)

6.2.1.4 MAJOR FIRE -- MAJOR POOL FIRE (707-D&D-7A)

6.2.1.1 SMALL FIRE -- CONTAINER (707-D&D-1)

This scenario involves the release of radioactive material caused by a small fire (less than 1 MW) occurring outside a glovebox in Building 707. Relevant details, assumptions, and parameters of the scenario are discussed in the following paragraphs and summarized in Table 6.2.1-1A.

Scenario Description

This scenario postulates a small fire involving TRU waste within a non-standard wooden crate and six drums. Because of its size, the fire is considered inadequate to activate the Fire Suppression System. As postulated, the fire consumes the TRU waste and internal plastic packaging, exposing the burning contents to the building atmosphere. Examples of the type and amount of combustibles that may produce a 1-megawatt (MW) fire include one gallon of flammable or combustible liquid or 27 cubic feet (ft³) of ordinary combustibles.

The dominant cause or initiator for this scenario is size reduction activities or other ignition sources such as transportation equipment (e.g., forklift fuel/oil fire), maintenance, or closure activities. However, other possible initiators include: exothermic chemical reactions from incompatible container contents; improper hot work; equipment malfunction (e.g., electrical short, overheat) or improperly operated or degraded electrical equipment; power supplies; and electrical power cords.

Activities

A small container fire could be initiated by any of the following primary activities:

- 1) Radioactive Waste Generation and Handling; 2) Decommissioning-Decontaminate, Dismantle, and Demolish.

Hazardous Material Handling is a secondary activity that could also be an initiator.

Assumptions

In addition to the generic assumptions listed at the beginning of Section 6.2, the following additional assumptions were also applied to this accident scenario:

- Using RADDOSE (Ref. 6-11), the scenario was modeled as a small, non-lofted fire involving confined materials.
- The fire is confined to the containers and does not breach adjacent structures or inventories.
- Release duration is 10 minutes, based on SARAH.
- The MAR is assumed to be one non-standard wooden waste crate, one closed TRU drum overpacked by 25%, and five closed TRU drums at the nominal inventory.
- Damage ratio (DR) is 20% for closed containers and 100% for wooden or open containers.

Material At Risk (MAR)

The containers (one non-standard wooden crate – 500 g; one drum – 250 g; and five drums – 200 g each) contain 1,750 g of TRU waste.

Accident Frequency

Without crediting preventive controls, the frequency of a fire within these types of containers is estimated to be *ANTICIPATED*, based on SARAH.

Accident Consequences and Risk

Without crediting mitigative controls, the consequence to the Public is *LOW* (1.3E-1 rem) and the consequence to the Worker is *MODERATE* (1.3E+1 rem). These consequences, when combined with an *ANTICIPATED* frequency, result in a risk *CLASS I* to the Worker, and *CLASS III* risk to the Public.

TABLE 6.2.1-1A. SUMMARY OF ACCIDENT SCENARIO 6.2.1.1
SMALL FIRE -- CONTAINER (707-D&D-1)

HAZARD/MAR	Small fire involving drums and crates. MAR = 1,750 g (1 crate @ 500 g, 1 drum @ 250 g, and 5 drums @ 200 g) Effective MAR = 750 g of confined materials (500 + 0.2(250) + 0.2(5)(200))							
ACCIDENT TYPE	Fire							
DOMINANT INITIATOR	Closure activities, or other ignition sources such as transportation equipment, maintenance hot work, or electrical malfunction.							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling and Decommissioning-Decontaminate, Dismantle, and Demolish Secondary: Hazardous Material Handling							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC	Anticipated	NA	Low 1.3E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
WORKER	Anticipated	Anticipated*	Moderate 1.3E+1 rem	Low** 1.3E+0 rem	I	III	PREVENTION: Combustible Control Program (Combustible Material and Hot Work Controls) MITIGATION: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	NONE IDENTIFIED

* The identified preventive controls are not credited to reduce this frequency.

**A dose reduction of 90% is taken. Typically, HEPA filters are tested to 99.9% filtration efficiency. For the purposes of the DBIO, only a 90% credit is taken to demonstrate the safety margin available. Should active HEPA filtration not be available, a static LPF of approximately 0.1 (dose reduction factor of 90%) is considered reasonable.

Control Set

The elements of the **Combustible Control Program (Combustible Material and Hot Work Controls)** are the preventive controls credited to reduce the risk to the Worker. These controls are not credited to reduce the frequency of the accident. However, by minimizing combustible loading and potential ignition sources, the Combustible Control Program reduces the probability of a small fire.

One mitigative control was credited to reduce the risk to the Worker: **Confinement [(One tested stage) exhaust HEPA filtration or static LPF]**. Confinement is judged to provide at a minimum a dose reduction factor of 90% (LPF = 0.1). The HEPA filters are tested to 99.9%

efficiency so a dose reduction factor on the order of 99.9% is available (actual factor is a little lower to account for dose conversion factor differences). However, if active HEPA filtration is not available, a static LPF from the building of 0.1 is still considered available. Therefore, the dose reduction credit taken in this scenario is at the lower end of the available credit. This control reduces the dose to the Worker to *LOW* (1.3E+0 rem). This reduction in consequence decreases the risk to the Worker from *CLASS I* to *CLASS III*. No controls for the Public are necessary to reduce risk to *CLASS III*. However, the controls selected for the Worker are considered to provide Defensive-in-Depth for the Public.

Defense In Depth

While there are no defense-in-depth controls for the Worker for this scenario, it is noted that the prevention controls associated with the Combustible Control Program were credited because of the control selection rules (e.g., prevention before mitigation) while the only control required to reduce the risk to the Worker is the building confinement. If the evaluation were performed from the standpoint of identifying only the required controls, the credited prevention controls for this scenario can be considered defense-in-depth. Additionally, other controls are provided and available through the Safety Management Programs, but are not credited for frequency, nor consequence, reduction.

Broadness

This bounding scenario, including the selected controls, encompass any localized small fires of several analyzed configurations involving drums and crates. The following table provides the details of the scenarios analyzed and determined bounded by the accident presented above.

TABLE 6.2.1-1B. ACCIDENTS BOUNDED BY SCENARIO 6.2.1.1***SMALL FIRE – CONTAINER (707-D&D-1)***

HAZARD/MAR	707-2-2 Small Fire in a Glovebox 1,000g Oxide in a glovebox 707-D&D-2 Small Fire in a Glovebox 1,000g Holdup in a glovebox 707-5-1 Small Plenum Fire 1,000g hold-up in a Zone I Plenum 707-D&D-1a Small Fire in Building 6,000g in three 10-gallon drums and 650g in three 55-gallon TRU waste drums 707-D&D-1b Small Pool Fire 1,200g in six drums @ 200g each 707-D&D-15 Small Airlock Fire 1,250g in six drums – 1 overpacked drum @250 g and five drums @ 200g 707-3-9A Small Fire on dock 1,050g in Five 55-gallon TRU waste drums							
ACCIDENT TYPE	Fire							
DOMINANT INITIATOR	Closure activities, or other ignition sources such as transportation equipment, maintenance hot work, or electrical malfunction.							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling and Decommissioning-Decontaminate, Dismantle, and Demolish Secondary: Hazardous Material Handling							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC								
707-2-2	Anticipated	NA	7.2E-2 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-2	Anticipated	NA	7.2E-3 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-5-1	Anticipated	NA	7.2E-3 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-1a	Anticipated	NA	9.4E-2 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-1b	Anticipated	NA	4.2E-2 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-15	Anticipated	NA	4.4E-2 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-3-9A	Anticipated	NA	3.7E-2 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
WORKER								
707-2-2	Anticipated	Anticipated*	7.1E+0 rem	7.1E-1rem	II	III	PREVENTION: Combustible Control Program (Combustible Material and Hot Work Controls) MITIGATION: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	NONE IDENTIFIED
707-D&D-2	Anticipated	NA	7.1E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-5-1	Anticipated	NA	7.1E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-1a	Anticipated	Anticipated*	9.4E+0 rem	9.4E-1 rem	I	III	PREVENTION: Combustible Control Program (Combustible Material and Hot Work Controls) MITIGATION: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	NONE IDENTIFIED
707-D&D-1b	Anticipated	NA	4.2E+0 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-15	Anticipated	NA	4.3E+0 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-3-9A	Anticipated	NA	3.6E+0 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED

* The identified preventive controls are not credited to reduce this frequency.

6.2.1.2 MEDIUM FIRE – CONTAINERS (707-D&D-3)

This scenario involves the release of radioactive material caused by a medium fire originating inside Building 707; because of pyrophoric materials, size reduction activities, or other ignition sources such as electrical equipment, maintenance, or closure activities taking place in the facility. Relevant details, assumptions, and parameters of the scenario are discussed in the following paragraphs and summarized in Table 6.2.1-2A.

Scenario Description

This scenario is postulated to initiate as a small fire among drums and crates, but the fire impacts additional inventory because of failure to adhere to the Combustible Control Program. Medium fires are assumed to involve more than only pyrophoric materials in containers.

The dominant cause or initiator for this scenario includes improper hot work, equipment malfunction (e.g., electrical short, overheating) or improperly operated or degraded electrical equipment, power supplies, or electrical power cords. Another possible initiator is an exothermic chemical reaction from incompatible container contents.

Activities

A medium container fire could be initiated by any of the following primary activities: 1) Radioactive Waste Generation and Handling; 2) Decommissioning-Decontaminate, Dismantle, and Demolish. Secondary activities involving Hazardous Material Handling could also be initiators.

Assumptions

In addition to the generic assumptions listed at the beginning of Section 6.2, the following additional assumptions were also applied to this accident scenario:

- Using RADDOSE (Ref. 6-11), the scenario was modeled as a medium, non-lofted fire, involving TRU waste containers.

- Per Sarah, a *Medium Fire* is defined as a 5-MW fire large enough to actuate the suppression system and is then suppressed by the wet-pipe sprinkler system or the Fire Department.
- Per SARAH, the *Medium Fire* is expected to burn for 15 minutes and affects a single glovebox or up to 18 drums or 5 waste crates (refer to CALC-RFP-00.1796-DJF, Ref. 6-15).
- DR is 100% for the wooden waste crate and 20% for the TRU waste drums.

Material At Risk (MAR)

The MAR is assumed to be 2,500 grams of confined materials.

Accident Frequency

Without crediting preventive controls, the frequency of a fire in a container is estimated to be *ANTICIPATED*, based on SARAH.

Accident Consequences and Risk

Without crediting mitigative controls, the consequence to the Public is *Low* ($1.3\text{E-}1$ rem) and *MODERATE* ($1.3\text{E+}1$ rem) for the Worker. These consequences, when combined with an *ANTICIPATED* frequency, result in a *CLASS III* risk to the Public and a *CLASS I* to the Worker.

TABLE 6.2.1-2A. SUMMARY OF ACCIDENT SCENARIO 6.2.1.2
MEDIUM FIRE – CONTAINER (707-D&D-3)

HAZARD/MAR	Medium fire involving drums and crates. MAR = 2,500 g (1 crate @ 500 g and 10 drums @ 200 g) Effective MAR = 900 g of confined materials (500 + 0.2 (10) (200))							
ACCIDENT TYPE	Fire							
DOMINANT INITIATOR	Size reduction activities or other ignition sources such as equipment, maintenance hot work, or electrical malfunctions.							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling and Decommissioning-Decontaminate, Dismantle, and Demolish Secondary: Hazardous Material Handling							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC	Anticipated	NA	Low 1.4E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
WORKER	Anticipated	Unlikely	Moderate 1.4E+1 rem	Low* 1.4E+0 rem	I	III	PREVENTION: Combustible Control Program (Combustible Material and Hot Work Controls) MITIGATION: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	Fire Suppression

A dose reduction of 90% is taken. Typically, HEPA filters are tested to 99.9% filtration efficiency. For the purposes of the DBIO, only a 90% credit is taken to demonstrate the safety margin available. Should active HEPA filtration not be available, a static LPF of approximately 0.1 (dose reduction factor of 90%) is considered reasonable.

Control Set

The elements of the **Combustible Control Program (Combustible Material and Hot Work Controls)** are the preventive controls credited to reduce the risk to the Worker. These controls reduce the frequency of the accident from *ANTICIPATED* to *UNLIKELY*. By minimizing combustible loading and potential ignition sources, the Combustible Control Program reduces the probability that a small fire propagates into a larger one. One mitigative control was credited to reduce the risk to the Worker: **Confinement [(One tested stage) exhaust HEPA filtration or static LPF]**. Confinement is typically judged to provide at a minimum a dose reduction factor of 90%. The HEPA filters are tested to 99.9% efficiency so a dose reduction factor on the order of 99.9% is available (actual factor is a little lower to account for dose conversion factor differences). However, if active HEPA filtration is not available, a static LPF from the building of 0.1 (dose reduction factor of 90%) is still considered available. Therefore, the dose reduction credit taken in this scenario is at the lower end of the available credit. This control reduces the

dose to the Worker to *Low* ($1.4\text{E}+0$ rem). This reduction in consequence decreases the Worker from *CLASS I* to *CLASS III*. No controls for the Public are required to reduce risk to *CLASS III*. However, the controls selected for the Worker inherently provide defense-in-depth to protect the Public.

Defense In Depth

R4-02 | The identified defense-in-depth control for the Worker for this scenario is the **Fire Suppression** system. The Fire Suppression system is credited in the larger fire scenarios as a preventive control to reduce the likelihood of a medium fire growing into a large fire. It is noted that although the preventive controls, associated with the Combustible Control Program, were credited, the only control required to reduce the risk to the Public and the Worker was building confinement. If the evaluation were performed from the standpoint of identifying only the required controls, the credited prevention controls for this scenario can be considered defense-in-depth.

Broadness

This bounding scenario, and the credited controls, bound the following Medium Fire scenarios as analyzed in the PHA:

TABLE 6.2.1-2B. ACCIDENTS BOUNDED BY SCENARIO 6.2.1.2
MEDIUM FIRE – CONTAINER (707-D&D-3)

HAZARD/MAR	707-D&D-3b Medium Pool Fire 2,450 g One overpacked TRU waste drum @ 250 g (DR=1), one TRU waste drum @ 200 g (DR=1), and ten TRU waste drums @ 200g (DR=0.2) 707-D&D-4 Medium Fire in a Glovebox 1,800g; hold-up in a Lathe 707-D&D-16 Medium fire Airlock 3,650g in 18 55-gallon TRU waste drums (one overpacked)							
ACCIDENT TYPE	Fire							
DOMINANT INITIATOR	Closure activities, or other ignition sources such as transportation equipment, maintenance hot work, or electrical malfunction.							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling and Decommissioning-Decontaminate, Dismantle, and Demolish Secondary: Hazardous Material Handling							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC								
707-D&D-3b	Anticipated	NA	1.4E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-4	Anticipated	NA	5.0E-2 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-16	Anticipated	NA	1.2E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
WORKER								
707-D&D-3b	Anticipated	Unlikely	1.4E+1 rem	1.4E+0 rem	I	III	PREVENTION: Combustible Control Program (Combustible Material and Hot Work Controls) MITIGATION: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	Fire Suppression
707-D&D-4	Anticipated	NA	4.9E+0 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-16 a)	Anticipated	Unlikely	1.2E+1 rem	1.2E+0	I	III	PREVENTION: Combustible Control Program (Combustible Material and Hot Work Controls) MITIGATION: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	Fire Suppression
b)	Anticipated	Extremely Unlikely	1.2E+1 rem	NA	I	III	PREVENTION: Combustible Control Program (Combustible Material and Hot Work Controls)	Fire Suppression

Scenario 707-D&D-16 is a Medium Airlock fire which, according to SARAH, is considered *ANTICIPATED*. This scenario is postulated to occur in Room 184 which, under normal condition has (Case a) filtered ventilation and would be mitigated with **Confinement [(One tested stage) exhaust HEPA filtration or static LPF]**. As such, under normal conditions, this

scenario would result in Risk Class *III* with an *UNLIKELY* frequency (due to the credit associated with the **Combustible Control Program**) and a consequence reduction to 1.2E+0 rem.

However, Room 184 may be open to atmosphere during waste transfers at the dock (Case b), and confinement cannot always be credited. Since Room 184 is not considered a true Airlock (Case b), and is not routinely used as such, a frequency reduction credit is taken to achieve *EXTREMELY UNLIKELY* for the occasional unmitigated case to yield Risk Class *III*.

6.2.1.3 LARGE FIRE -- CONTAINERS (707-D&D-5)

This scenario involves the release of radioactive material via a large fire (5 MW to 10 MW) caused by not adhering to the Combustible Control Program and an error in drum handling inside Building 707. Relevant details, assumptions, and parameters of the scenario are discussed in the following paragraphs and summarized in Table 6.2.1-3A.

Scenario Description

This scenario is postulated to initiate as a small fire among drums and crates, but the fire impacts additional inventory due to failure to adhere to the Combustible Control Program. In this scenario, the fire propagates from one container to another while growing in intensity. This large fire may involve combustibles such as a stack of 31 wood pallets, or 10 rigid plastic drum liners, or 8 gallons of flammable or combustible liquid, or 5 wooden waste crates plus 135 ft³ of ordinary combustibles, or 269 ft³ of ordinary combustibles.

In the event the fire propagates into the plenum, several systems are designed to provide non-credited safety functions (e.g., automatic activation of plenum deluge system and securing recirculation fans and valves).

The dominant cause or initiator for this scenario includes improper hot work, equipment malfunction (e.g., electrical short, overheat) or improperly operated or degraded electrical equipment, power supplies, or electrical power cords. Another possible initiator is an exothermic chemical reaction from incompatible container contents.

Activities

A large container fire could be initiated by any of the other smaller container fires or specifically:

- 1) Radioactive Waste Generation and Handling; 2) Decommissioning-Decontaminate, Dismantle, and Demolish. Secondary activities involving Hazardous Material Handling could also be initiators.

Assumptions

In addition to the generic assumptions listed at the beginning of Section 6.2, the following additional assumptions were also applied to this accident scenario:

- Using RADDOSE (Ref. 6-11), the scenario was modeled as a large non-lofted fire involving confined materials.
- Per SARAH Task 19, a *Large Fire* is defined as a 10-MW fire large enough to breach some structures, actuate the suppression system, and is eventually suppressed by sprinklers.
- Per SARAH, the *Large Fire* burns for 30 minutes and affects the entire dispersible module inventory or up to 30 drums or 9 waste crates. This analysis considers a MAR of 1 non-standard wooden waste crate and 28 closed TRU drums at the nominal inventory.
- DR is 20% for closed containers and 100% for wooden or open containers. A DR of 100% was applied to the hold-up.

Material At Risk (MAR)

The MAR is assumed to be 6,100 g (1 crate @ 500-g of surface contamination and 28 TRU waste drums @ 200 g Pu).

Accident Frequency

Without crediting preventive controls, the frequency of a fire involving containers is estimated to be *ANTICIPATED* based on SARAH.

Accident Consequences and Risk

Without crediting mitigative controls, the consequence to the Public is *MODERATE* (2.3E-1 rem) and to the Worker is *HIGH* (2.3E+1 rem). These consequences, when combined with an *ANTICIPATED* frequency, result in a *CLASS I* risk to both, the Public the Worker.

TABLE 6.2.1-3A. SUMMARY OF ACCIDENT SCENARIO 6.2.1.3
LARGE FIRE -- CONTAINERS (707-D&D-5)

HAZARD/MAR	Large fire involving drums and crates. MAR = 6,100 g (1 crate @ 500 g and 28 drums @ 200g) Effective MAR = 1,620 g of confined materials (500 + 0.2 (28) (200))							
ACCIDENT TYPE	Fire							
DOMINANT INITIATOR	Not adhering to Combustible Control Program requirements AND an error in drum handling AND failure of the building sprinkler system							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling and Decommissioning-Decontaminate, Dismantle, and Demolish Secondary: Hazardous Material Handling							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC	Anticipated	NA	Low 2.3E-1rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
WORKER	Anticipated	Extremely Unlikely	Moderate 2.3E+1 rem	Low 2.3E+0 rem	I	IV	PREVENTION: 1. Combustible Control Program (Combustible Material and Hot Work Controls) 2. Fire Suppression MITIGATION: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	• Plenum Deluge

Control Set

The preventive controls credited to reduce the risk to the Worker are the elements of the **Combustible Control Program (Combustible Material and Hot Work Controls)** and the **Fire Suppression System**. These controls reduce the frequency of the accident from *ANTICIPATED* to *EXTREMELY UNLIKELY* (one frequency bin for the Combustible Control Program and one frequency bin for the Fire Suppression System). The Combustible Control Program and the Fire Suppression System both reduce the probability that a fire propagates into a larger one. Combined with a *MODERATE* consequence, this reduction in frequency decreases the risk to the Worker from *CLASS I* to *CLASS III*.

One mitigative control was credited to reduce the risk to the Worker: **Confinement [(One tested stage) exhaust HEPA filtration or static LPF]**. Confinement is typically judged to provide at a minimum a dose reduction factor of 90%. The HEPA filters are tested to 99.9% efficiency so a dose reduction factor on the order of 99.9% is available (actual factor is a little lower to account for dose conversion factor differences). However, if active HEPA filtration is

not available, a static LPF from the building of 0.1 (dose reduction factor of 90%) is still considered available. Therefore, the dose reduction credit taken in this scenario is at the lower end of the available credit. This control reduces the dose to the Worker to *Low* ($2.3\text{E}+0$ rem). This reduction in consequence, combined with the frequency reduction, decreases the Worker from *CLASS I* to *CLASS IV*. No preventive or mitigative controls for the Public are necessary because the unmitigated risk is *CLASS III*. However, any controls credited for the Worker are considered defense-in-depth for the Public for reducing the risk to the Public.

Defense In Depth

In addition to the credited controls specified in the previous paragraphs, **Plenum Deluge (manually activated)** is also available to prevent or mitigate this accident for the Public and the Worker as discussed below.

The Plenum Deluge System does not have a direct impact on the dose, but it permits crediting the HEPA filtration system. If hot gases or embers were to be drawn into the ventilation plenum, the plenum deluge system would cool or extinguish the influent and protect the downstream HEPA filters. Although this system operates automatically, the manual function, upstream of the demisters, is credited to provide the necessary protection to the HEPA filters.

Broadness

This bounding scenario encompasses other similar events with similar MAR and Risk within the subject locations for D&D activities, such as fires involving metal waste crates or combinations of drums and crates. The controls credited in the Bounding Scenario are also applicable to reducing the Risk Class for the following scenarios. The following table provides a sampling of accident scenarios bounded by the above.

TABLE 6.2.1-3B. ACCIDENTS BOUNDED BY SCENARIO 6.2.1.3
LARGE FIRE – CONTAINER (707-D&D-5)

HAZARD/MAR	707-D&D-5a Large Pool Fire 3,500g One overpacked TRU waste drum @ 250 g (DR=1.0), one TRU waste drum @ 200 g (DR=1.0) and 17 TRU waste drums @ 200 g (DR=0.2) 707-D&D-6 Large Module Fire 16,000g, of Hold-up in a worst case Module 707-D&D-17 Large Fire Airlock 5,650g, 28 TRU waste drums (one overpacked) (DR=0.2) 707-D&D-17A Large Fire in Outdoor Staging Area 6,050g, 30 TRU waste drums (one overpacked) (DR=0.2)							
ACCIDENT TYPE	Fire							
DOMINANT INITIATOR	Closure activities, or other ignition sources such as transportation equipment, maintenance hot work, or electrical malfunction.							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling and Decommissioning-Decontaminate, Dismantle, and Demolish Secondary: Hazardous Material Handling							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC								
707-D&D-5a	Anticipated	NA	1.6E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-6	Anticipated	NA	1.3E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-17	Anticipated	NA	1.6E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-17A	Anticipated	NA	1.7E-2 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
WORKER								
707-D&D-5a	Anticipated	Extremely Unlikely	1.6E+1 rem	1.6E+0 rem	I	IV	PREVENTION: 1. Combustible Control Program (Combustible Material and Hot Work Controls) 2. Fire Suppression MITIGATION: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	Plenum Deluge
707-D&D-6	Anticipated	Extremely Unlikely	1.3E+1 rem	1.3E+0 rem	I	IV		
707-D&D-17 a)	Anticipated	Extremely Unlikely	1.6E+1 rem	1.6E+0 rem	I	IV	PREVENTION: 1. Combustible Control Program (Combustible Material and Hot Work Controls) 2. Fire Suppression MITIGATION: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	Plenum Deluge
b)	Anticipated	Extremely Unlikely	1.6E+1 rem	NA	I	III	PREVENTION: 1. Combustible Control Program (Combustible Material and Hot Work Controls) 2. Fire Suppression	NOT REQUIRED
707-D&D-17A	Anticipated	NA	6.1E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED

Scenario 707-D&D-17 is a Large Airlock fire which, according to SARAH, is considered *ANTICIPATED*. This scenario is postulated to occur in Room 184 which, under normal condition has (Case a) filtered ventilation and would be mitigated with **Confinement [(One tested stage) exhaust HEPA filtration or static LPF]**. As such, under normal conditions, this scenario would result in risk Class *IV* with an *UNLIKELY* frequency (due to the credit associated with the **Combustible Control Program**) and a consequence reduction to 1.6E+0 rem. However, Room 184 may be open to atmosphere during waste transfers at the dock (Case b), and confinement cannot always be credited. Since Room 184 is not considered a true Airlock (Case b), and is not routinely used as such, a frequency reduction credit is taken to achieve Extremely Unlikely for the occasional unmitigated case to achieve risk *CLASS III* to the Worker.

6.2.1.4 MAJOR POOL FIRE (707-D&D-7A)

This scenario involves the release of radioactive material caused by a major fire (greater than 10 MW), impacting a TRU waste drum storage array in Building 707. Relevant details, assumptions, and parameters of the scenario are discussed in the following paragraphs and summarized in Table 6.2.1-4A.

Scenario Description

A major pool fire could result from breaching a 55-gallon "bung" drum containing combustible liquids with a resulting pool forming in, and around, a TRU waste drum storage array coincident with any of the previously identified D&D fires inside Building 707. This scenario assumes the elements of the Combustible Control Program are not adhered to and the Fire Suppression System fails to limit the size of the fire. A major pool fire is assumed to have sufficient intensity to breach TRU waste drums and expel waste inventory from drums. Other drums experience lid loss with no resultant expulsion of container contents. The balance of the drum inventory involved in the pool fire is assumed to experience seal damage. This scenario can potentially occur in any area within Building 707 where TRU waste drums may be stored in the vicinity of 55-gallon "bung" drums. The resultant pool is assumed to form around the waste drums, allowing for total drum engulfment in the fire. Details regarding the model are delineated in the *Assumptions* subsection.

In the event a fire propagates into the plenum, several systems are designed to provide non-credited safety functions (e.g., automatic activation of the plenum deluge system and securing the recirculation fans and valves).

The dominant cause or initiator for this scenario is malfunction of, or improper operation of, electrical or thermal equipment that initiates a fire within a TRU waste drum storage area coincident with a breach of a 55-gallon "bung" drum containing flammable/combustible liquids and concurrent failure of: 1) the Combustible Control Program; and 2) the building fire suppression system.

Activities

A major pool fire could be initiated by any of the other fires or specifically: 1) Radioactive Waste Generation and Handling; 2) Decommissioning-Decontaminate, Dismantle, and Demolish. Secondary activities involving Hazardous Material Handling could also be initiators.

Assumptions

In addition to the generic assumptions listed at the beginning of Section 6.2, the following additional assumptions were also applied to this accident scenario:

- Using RADIDOSE (Ref. 6-11), the scenario was modeled as a major non-lofted fire involving unconfined non-combustible surfaces, confined materials, and powders.
- The fire is assumed to propagate from a small fire to a major fire through concurrent failures of the Combustible Control Program, and the building sprinkler system.
- Per SARAH, A *Major Fire* is defined as a fire that burns out of control with no effective suppression.
- Per SARAH, a *Major Fire* reaches flashover conditions and is expected to burn for 60 minutes or more.
- Per SARAH Task 19 the following Damage Ratios are assumed:
 1. 25% of the engulfed drums experience lid loss with 33% (DR = 0.33) of the waste material ejected from the drum (i.e., unconfined-combustible material).
 2. Material remaining in drums suffering lid loss with expulsion (DR = 0.67) is modeled as confined-combustible material.

3. The balance of the engulfed drums (i.e., 75%) are assigned a DR of 0.50 and modeled as confined-combustible material.
4. 30% of the drums impinged by the flame front (i.e., on the periphery of the pool) experience lid loss with a DR of 1.0 and modeled as confined-combustible material.
5. The balance of the impinged drums (i.e., 70%) are assigned a DR of 0.70 and modeled as confined-combustible material.

Material At Risk (MAR)

R4-02 | The MAR is 6,850 g (33 TRU waste drums @ 200 g Pu and 1 TRU waste drum @ 250 g Pu).

Accident Frequency

The initiator frequency alone for a fire is *ANTICIPATED*, based on engineering judgment and historical occurrences of this size of fire within the DOE complex. However, the only way for a major fire to occur would be prolonged programmatic failures of the Combustible Control Program and the Fire Suppression System. If these two controls are in place, a fire may still occur; but the magnitude of the fire would be much less and would be similar in frequency and consequence to the previously analyzed fire scenarios. Therefore, the frequency for a major fire is estimated to be *UNLIKELY*.

Accident Consequences and Risk

Without crediting mitigative controls, the consequence to the Public is *MODERATE* and to the Worker is *HIGH* (1.5 E+0 rem and 1.5E+2 rem, respectively). These consequences, when combined with an *UNLIKELY* frequency, result in a *CLASS II* risk to the Public and *CLASS I* to the Worker.

TABLE 6.2.1-4A. SUMMARY OF ACCIDENT SCENARIO 6.2.1.4
MAJOR FIRE – MAJOR POOL FIRE (707-D&D-7A)

HAZARD/MAR	707-D&D-7a Major Pool Fire in a TRU waste storage area. MAR = 6,850g (34 TRU waste drums with over-packed drum)							
ACCIDENT TYPE	Fire (Major)							
DOMINANT INITIATOR	Failure of electrical or thermal equipment, that initiates a fire within the glovebox or propagates into the glovebox AND concurrent failure of operator adherence to Combustible Control Program requirements AND failure of the building sprinkler system							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling and Decommissioning-Decontaminate, Dismantle, and Demolish Secondary: Hazardous Material Handling							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC	Unlikely	Extremely Unlikely	Moderate 1.5E+0 rem	NA	II	III	PREVENTION: 1. Combustible Control Program (Combustible Material and Hot Work Controls) 2. Fire Suppression	<ul style="list-style-type: none"> Plenum Deluge Confinement [(One tested stage) exhaust HEPA filtration or static LPF]
WORKER	Unlikely	Extremely Unlikely	High 1.5E+2 rem	Moderate 1.5E+1 rem	I	III	PREVENTION: 1. Combustible Control Program (Combustible Material and Hot Work Controls) 2. Fire Suppression MITIGATION: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	<ul style="list-style-type: none"> Plenum Deluge

* A dose reduction of 90% is taken. Typically, HEPA filters are tested to 99.9% filtration efficiency. For the purposes of the DBIO, only a 90% credit is taken to demonstrate the safety margin available. Should active HEPA filtration not be available, a static LPF of approximately 0.1 (dose reduction factor of 90%) is considered reasonable.

Control Set

The preventive controls credited to reduce the risk to the Public and Worker are the **Combustible Control Program (Combustible Material and Hot Work Controls)** and the **Fire Suppression System**. These controls reduce the frequency of the accident from *UNLIKELY* TO *EXTREMELY UNLIKELY*. The Combustible Control Program and the Fire Suppression System reduce the probability that a fire propagates into a larger one. Unlike the large fires described in the previous two sections, only a one bin frequency reduction is assumed for the major fire. This is because the estimated frequency without prevention already has a built in assumption of a partial failure of some of the credited controls. Therefore, it is considered appropriate to limit

the frequency reduction from these controls to one bin. With an *EXTREMELY UNLIKELY* frequency and a *MODERATE* dose, the risk to the Public is *CLASS III*.

One mitigative control was credited to reduce the risk to the Worker: **Confinement [(One tested stage) exhaust HEPA filtration or static LPF]**. Confinement is judged to provide at a minimum a dose reduction factor of 90% ($LPF=0.1$). The HEPA filters are tested to 99.9% efficiency so a dose reduction factor on the order of 99.9% is available (actual factor is a little lower to account for dose conversion factor differences). However, if active HEPA filtration is not available, a static LPF from the building of 0.1 (dose reduction factor of 90%) is still considered available. Therefore, the dose reduction credit taken in this scenario is at the lower end of the available credit. This control reduces the dose to the Worker to *MODERATE* ($1.5E+1$ rem). This reduction in consequence decreases the risk to the Worker to *CLASS III*.

It should be noted that although preventive controls are not typically credited for consequence reduction, the specific combustible control credited for the Worker is the FHA requirement to segregate "bulk" flammable/combustible liquid wastes from other waste forms. Additionally, the Fire Protection SMP limits the Pu content of flammable/combustible liquids stored in 55-gallon "bung" drums to ≤ 1 milligram per liter. With the FHA imposed segregation requirement, coupled with the allowable Pu content, a major pool fire, assuming one breached "bung" drum would involve 0.132 grams of Pu with prevented/unmitigated consequence of $2.3E-1$ rem to the Worker.

Defense In Depth

In addition to the credited controls specified in the previous paragraphs, **Plenum Deluge (manually activated)** is also available to prevent or mitigate this accident for the Public and the Worker as discussed below.

Confinement [(One tested stage) exhaust HEPA filtration or static LPF] provides a dose reduction factor but the dose reduction is not credited when considered a Defense in Depth Control. If active exhaust HEPA filtration is available, a dose reduction factor of up to 99.9% (actual factor is a little lower to account for dose conversion factor differences) is available. This is the standard to which HEPA filters are tested. Should active HEPA filtration not be available, a static LPF is available. A dose reduction factor of 90% is considered reasonable for a static LPF (LPF=0.1). The Plenum Deluge System does not have a direct impact on the dose, but it permits crediting the HEPA filtration system in the case for the Worker. If hot gases or embers were to be drawn into the ventilation plenum, the plenum deluge system would cool or extinguish the influent and protect the downstream HEPA filters. Although this system operates automatically, the manual function, upstream of the demisters, is credited to provide the necessary protection to the HEPA filters.

Broadness

This bounding scenario encompasses other similar events with similar MAR and Risk within the subject locations for D&D activities, such as fires involving metal waste crates or combinations of drums and crates. The following table provides a sampling of accident scenarios bounded by the above.

TABLE 6.2.1-4B. ACCIDENTS BOUNDED BY SCENARIO 6.2.1.4
MAJOR FIRE – MAJOR POOL FIRE (707-D&D-7A)

HAZARD/MAR	707-D&D-7 Major Fire – Building 14,000g in 55-gallon TRU waste drums, 1,000 g Oxide in an 8801, and 53,000 Hold-up in a worst case Module							
	707-USQD-1 Major Fire – Building 778 4,200g holdup in Facility							
ACCIDENT TYPE	Fire							
DOMINANT INITIATOR	Closure activities, or other ignition sources such as transportation equipment, maintenance hot work, or electrical malfunction.							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling and Decommissioning-Decontaminate, Dismantle, and Demolish Secondary: Hazardous Material Handling							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC								
707-D&D-7	Unlikely	Extremely Unlikely	8.9E-1 rem	NA	II	III	PREVENTION: 1. Combustible Control Program (Combustible Material and Hot Work Controls) 2. Fire Suppression	<ul style="list-style-type: none"> Plenum Deluge Confinement [(One tested stage) exhaust HEPA filtration or static LPF]
707-USQD-1	Unlikely	NA	2.4E-2 rem	NA	III	NA	NONE REQUIRED	NONE REQUIRED
WORKER								
707-D&D-7	Unlikely	Extremely Unlikely	8.9E+1 rem	8.9E+0 rem	I	III	PREVENTION: 1. Combustible Control Program (Combustible Material and Hot Work Controls) 2. Fire Suppression MITIGATION: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	<ul style="list-style-type: none"> Plenum Deluge
707-USQD-1	Unlikely	NA	2.4E+0 rem	NA	III	NA	NONE REQUIRED	NONE REQUIRED

6.2.2 Spills

The hazard analysis process identified numerous scenarios involving spills of radioactive materials. This subsection presents analyses of one scenario within the Building 707 Complex.

- SPILL – Container Spill Inside Building (707-6-13)

6.2.2.1 SPILL – CONTAINER SPILL INSIDE BUILDING (707-6-13)

This loss of containment/confinement scenario involves dropping a 10-gallon drum during material transfer activities in Building 707, resulting in an energetic release of radioactive material. Relevant details, assumptions, and parameters of the scenario are discussed in the following paragraphs and summarized in Table 6.2.2-1A.

Scenario Description

This scenario is postulated to involve one 10-gallon drum containing Pu Oxide. For this scenario, it is postulated that during D&D activities, a 10-gallon drum is dropped or breached during material transfer activities. The damage/breach is assumed to spill the entire contents of one of the 8801 cans in the 10-gallon drum.

Activities

Dropping a 10-gallon drum during material transfer activities could be initiated by any of the following primary activities: 1) Radioactive Waste Generation and Handling; 2) Decommissioning-Decontaminate, Dismantle, and Demolish. Secondary activities involving Hazardous Material Handling could also be initiators.

Assumptions

In addition to the generic assumptions listed at the beginning of Section 6.2, the following additional assumptions were also applied to this accident scenario:

- Using RADIDOSE, the scenario was modeled as spill involving powder.
- No collateral damage is assumed to occur, per SARAH.
- Release duration is 10 minutes, based on SARAH.

Material At Risk (MAR)

The total MAR is estimated at 2,000 g of Pu Oxide in one 8801 can inside a 10-gallon drum.

Accident Frequency

Without crediting preventive controls, the frequency of a spill from dropping a 10-gallon drum is *ANTICIPATED*, based on engineering judgment and historical occurrences of this type of spill within the DOE complex.

Accident Consequences and Risk

Without crediting mitigative controls, the consequence to the Public is *LOW* (1.4E-1 rem) and the consequence to the Worker is *MODERATE* (1.4E+1 rem) resulting in a *CLASS III* risk to the Public and a *CLASS I* risk to the Worker.

TABLE 6.2.2-1A. SUMMARY OF ACCIDENT SCENARIO 6.2.2.1
SPILL — CONTAINER SPILL INSIDE BUILDING (707-6-13)

HAZARD/MAR	Container spill causing a release of radioactive materials. MAR = 2,000 g of oxide in a 10-gallon drum. Effective MAR = 2,000 g of Pu powder							
ACCIDENT TYPE	Spill of Radioactive Materials							
DOMINANT INITIATOR	Release of radioactive material during bag-in or bag-out operations.							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling and Decommissioning-Decontaminate, Dismantle, and Demolish Secondary: Hazardous Material Handling							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC	Anticipated	NA	Low 1.4E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
WORKER	Anticipated	NA	Moderate 1.4E+1 rem	Low 1.4E+0 rem	I	III	MITIGATION: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	NONE IDENTIFIED

Control Set

No controls for the Public are necessary because the unmitigated risk is *CLASS III*. One mitigative control was credited to reduce the risk to the Worker: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]. Confinement is judged to provide at a minimum a dose reduction factor of 90% (LPF=0.1). The HEPA filters are tested to 99.9% efficiency so a dose reduction factor on the order of 99.9% is available (actual factor is a little lower to account for dose conversion factor differences). However, if active HEPA filtration is not available, a static LPF from the building of 0.1 (dose reduction factor of 90%) is still considered available. Therefore, the dose reduction credit taken in this scenario is at the lower end of the available credit. This control reduces the dose to the Worker to *LOW* (1.4E+0 rem). This reduction in consequence decreases the risk to the Worker to *CLASS III*.

Defense In Depth

Since no controls are required to reduce the risk for the Public, no defense-in-depth controls are identified for this scenario. Although this scenario requires a mitigative control to reduce the risk to the Worker to *Class III*, this scenario involves purely human error in dropping the 10-gallon drum and initiating the accident. As such, no defense-in-depth controls can be identified.

Broadness

This scenario, and its credited control, represents the bounding spill event analyzed in the PHA.

The following events are bounded by this scenario:

TABLE 6.2.2-1B. ACCIDENTS BOUNDED BY SCENARIO 6.2.2.1
SPILL – CONTAINER SPILL INSIDE BUILDING (707-6-13)

HAZARD/MAR	707-D&D-11 Spill – Glovebox/Chainveyor 4,000g; holdup in a component.							
	707-6-32 Container Impact inside Building 1,000g (1 8801 Can)							
	707-USQD-3 Spill – Maintenance Activity 0 g (Radiological uptake during maintenance activities, uptake cannot be quantified)							
	707-USQD-4 Building 778 Spill 4,000g; holdup in a component							
	707-3-14 Drum Impact on Dock 450g (1 drum @250g and 1 drum @200g)							
	707-D&D-10 Waste Box Spill 400g (1 overpacked standard waste box)							
	707-5-14 Ventilation Breach Tank Overflow Inside Building 1,000g (heat chamber holdup release to process tank upon actuation of plenum deluge)							
	707-3-18 Spill – Container Overpressurization on Dock 250g (1 overpacked drum)							
	707-2-11 Spill – Container Overpressurization Inside Building 250g (1 overpacked drum)							
	ACCIDENT TYPE Spill							
DOMINANT INITIATOR	Container impact/drop causing a release inside the building							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling and Decommissioning-Decontaminate, Dismantle, and Demolish Secondary: Hazardous Material Handling							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC								
707-D&D-11	Anticipated	NA	4.8E-02 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-6-32	Anticipated	NA	7.1E-02 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-USQD-3*	Anticipated	NA	Low	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-USQD-4	Anticipated	NA	4.8E-02 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-3-14	Anticipated	NA	1.6E-02 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-10	Anticipated	NA	1.4E-02 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-5-14	Anticipated	NA	4.8E-03 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-3-18	Anticipated	NA	8.7E-04 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-2-11	Anticipated	NA	8.7E-04 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
WORKER								
707-D&D-11	Anticipated	NA	4.8E+0 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-6-32	Anticipated	NA	7.1E+0 rem	7.1E-1	I	III	MITIGATION: Confinement [(One tested stage) exhaust HEPA filtration or static LPP]	NONE IDENTIFIED
707-USQD-3*	Anticipated	NA	Low	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-USQD-4	Anticipated	NA	4.8E+0 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-3-14	Anticipated	NA	1.6E+0 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-10	Anticipated	NA	1.4E+0 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-5-14	Anticipated	NA	4.8E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-3-18	Anticipated	NA	8.7E-2 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-2-11	Anticipated	NA	8.7E-2 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED

* This scenario involves a radiological release resulting in a direct exposure to the worker. Dose consequences cannot be quantified.

6.2.3 Explosions

The hazard analysis process identified numerous scenarios involving explosions that either directly or indirectly resulted in releases of radioactive materials. Although some of the scenarios could also be classified as spills or fires, they are included in the *EXPLOSIONS* category, based on their release mechanism. This subsection presents an analysis of a scenario that addresses explosions within the Building 707 Complex:

- EXPLOSION – MODULE VAPOR CLOUD (707-D&D-9).

6.2.3.1 EXPLOSION – MODULE VAPOR CLOUD (707-D&D-9)

This scenario involves the release of radioactive material caused by a vapor cloud explosion on the first floor of Building 707. Relevant details, assumptions, and parameters of the scenario are discussed in the following paragraphs and summarized in Table 6.2.3-1A.

Scenario Description

Hot work will be routinely conducted for closure activities in Building 707. In order to perform such tasks, flammable/explosive gas (e.g., acetylene) cylinders will be required. If the contents of these cylinders are accidentally released, there is a potential for a flammable vapor cloud, or vapor-jet explosion. An explosion would initiate a pressure pulse in the room and could potentially breach containers or gloveboxes. In addition, depending upon the location of the explosion, there may be sufficient force to impact the ventilation system ducting. There are a variety of locations where this scenario could occur. For this scenario, flammable/explosive gas is slowly released from a failed tank/cylinder in a Module allowing a vapor cloud to form. The resultant release is of sufficient concentration to cause a vapor cloud explosion to occur given an ignition source (i.e., subsequent hotwork in the module).

The dominant cause or initiator for this scenario is a leak (e.g., cylinder/tank regulator nozzle/valve failure) of a flammable/explosive gas cylinder that generates a vapor cloud that is ignited to create an explosion.

Activities

A vapor-cloud explosion could be initiated by activities as part of General Facility Operations, Hazardous Material Handling, Radioactive Waste Generation and Handling, and Decommissioning Activities.

Assumptions

In addition to the generic assumptions listed at the beginning of Section 6.2, the following additional assumptions were also applied to this accident scenario:

- Vapor cloud explosions resulting in overpressures greater than 1 pound per square inch are sufficient to breach containers or confinements.
- Using RADDOSE (Ref. 6-11), the scenario was modeled as a spill of unconfined non-combustible surfaces.
- The release duration of the explosion is 10 minutes (per the default value in SARAH used to bound the analysis results).
- DR is 100% for “loose” surface contamination and 10% for “fixed” contamination. Due to previous Duct Remediation activities, 30% of the measured hold-up is assumed to be “loose” and 70% “fixed” surface contamination. A DR of 100% is assumed for the 8801 can.

Material At Risk (MAR)

The MAR for this scenario is assumed to be 8,000 g, based upon the maximum estimated holdup (7,000 g) in the most at risk module due to total room volume, and 1,000 g of plutonium powder in an 8801 can inside of a glovebox.

Accident Frequency

Without crediting preventive controls, the frequency of a pressurized cylinder regulator nozzle/valve failure is *UNLIKELY*, based on SARAH. Slow leaks from a gas cylinder are not postulated to cause this scenario because over time, a slow leak will disperse (aided by the ventilation system), and the concentration of the resulting cloud will not be sufficient to result in an explosion. The conditional probability of this type of explosion is factored into the frequency determination in accordance with SARAH.

Accident Consequences and Risk

Without crediting mitigative controls, the consequence to the Public is *LOW* (3.8E-1 rem) and to the Worker is *HIGH* (3.8 E+1 rem). These consequences, when combined with an *UNLIKELY* frequency, result in a *CLASS I* risk to the Worker and *CLASS III* risk to the Public.

TABLE 6.2.3-1A. SUMMARY OF ACCIDENT SCENARIO 6.2.3.1
EXPLOSION – MODULE VAPOR-CLOUD (707-D&D-9)

HAZARD/MAR	Release of radioactive material caused by a vapor-cloud explosion on the first floor. MAR = 7,000 g of holdup and 1,000 g of Pu powder in an 8801 can located in the glovebox.							
ACCIDENT TYPE	Explosion							
DOMINANT INITIATOR	Failure of flammable/explosive gas cylinder							
VULNERABLE DBIO ACTIVITY	Primary: General Facility Operations, Hazardous Material Handling, Radioactive Waste Generation and Handling, and Decommissioning Activities Secondary: N/A							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC	Unlikely	NA	Low 3.8 E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
WORKER	Unlikely	Extremely Unlikely	High 3.8 E+1 rem	Low 3.8 E+0 rem	I	IV	PREVENTIVE: Flammable/Explosive Gas Controls MITIGATIVE: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	NONE IDENTIFIED

Control Set

No preventive, or mitigative, controls are required to reduce the Risk Class of this scenario to the Public. However, both preventive and mitigative controls are required to reduce the risk to the Worker. One mitigative control credited in other accident scenarios, to reduce the risk to the Worker, is available: **Confinement [(One tested stage) exhaust HEPA filtration or static LPF]**. Confinement is judged to provide at a minimum a dose reduction factor of 90% (LPF=0.1). The HEPA filters are tested to 99.9% efficiency so a dose reduction factor on the order of 99.9% is available (actual factor is a little lower to account for dose conversion factor differences). However, if active HEPA filtration is not available, a static LPF from the building of 0.1 (dose reduction factor of 90%) is still considered available. Therefore, the dose reduction

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credit taken in this scenario is at the lower end of the available credit. This control reduces the dose to the Worker to *LOW* (3.8 E+0 rem).

A preventive control is also available and involves **flammable/explosive gas control**. The flammable/explosive gas control limits the type and volume of flammable gasses allowed to be stored in areas vulnerable to vapor cloud explosion accidents. The flammable/explosive gas control combined with the conditional probability that a leak from a flammable/explosive gas cylinder results in an explosion are qualitatively estimated to reduce the frequency of this event from *UNLIKELY* to *EXTREMELY UNLIKELY*. With an *EXTREMELY UNLIKELY* frequency and a *LOW* consequence, the risk to the Worker is reduced to *CLASS IV*.

As mentioned in the assumptions, room volume is the primary consideration for determining the affects of a vapor cloud explosion. Room volumes allowing overpressures in excess of one pound per square foot (1 psi) results in damage to confinements and building structures depending on the flammable/explosive gas in use.

In the case of propane, cylinders containing greater than, or equal to, 1 pound can yield overpressures in excess of 1 psi if a vapor cloud were to be formed (Ref. 6-3). Therefore, **use of any other flammable/explosive gas besides acetylene in the facility would be allowed only via the USQD process.**

For acetylene, the limit would be 130 cubic feet for rooms/modules in the facility with volumes less than 110,000 cubic feet. Based upon hold-up measurements, and room volume, K module represents the highest risk area within the facility. As such, **use/storage of acetylene in K module is limited to 48 cubic feet.** A vapor cloud explosion involving less than or equal to 48 cubic feet of acetylene will not yield an overpressure greater than 1 psi and can not compromise the integrity of waste containers, gloveboxes, Zone I ducting, and/or chainveyors (Ref. 6-3).

No storage control is required for lecture bottles (≤ 2 cubic feet at STP), regardless of the type of gas.

Defense In Depth

No defense in depth controls to mitigate the accident for the Public and the Worker are required for this scenario. However, the controls credited for the Worker are considered defense-in-depth for the Public. No defense-in-depth controls are identified for the Worker.

Broadness

This scenario, and the credited controls, bounds the accidents presented in the table below.

TABLE 6.2.3-1B. ACCIDENTS BOUNDED BY SCENARIO 6.2.3.1**EXPLOSION – MODULE VAPOR-CLOUD (707-D&D-9)**

HAZARD/MAR	707-D&D-9A Explosion – Module Turbulent Jet 4,000g holdup							
	707-5-7 Explosion – 2 nd Floor Turbulent Jet 1,000 g (Plenum hold-up)							
	707-USQD-2 Building 778 Explosion – Turbulent Jet 4,000g (4,000g in component in transit through 778)							
	707-D&D-8 Container 250g (1 overpacked waste drum)							
	707-2-7 Hydrogen Deflagration in a Drum 250g (1 overpacked waste drum)							
	707-2-7A Hydrogen Deflagration in a 10-Gallon Drum 1,000g (recovered Pu hold-up)							
	707-3-11 Hydrogen Deflagration – Drum on Dock 250g (1 overpacked waste drum)							
	707-3-11A Hydrogen Deflagration – 10-Gallon Drum on Dock 1,000g (recovered Pu hold-up)							
ACCIDENT TYPE	Fire							
DOMINANT INITIATOR	Closure activities, or other ignition sources such as transportation equipment, maintenance hot work, or electrical malfunction.							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling and Decommissioning-Decontaminate, Dismantle, and Demolish Secondary: Hazardous Material Handling							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC								
707-D&D-9A	Unlikely	NA	4.8E-2 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-5-7	Unlikely	NA	1.2E-2 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-USQD-2	Unlikely	NA	4.8E-2 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-8	Unlikely	NA	1.2E-2 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-2-7	Unlikely	NA	1.2E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-2-7A	Unlikely	NA	1.7E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-3-11	Unlikely	NA	1.2E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-3-11A	Unlikely	NA	1.7E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
WORKER								
707-D&D-9A	Unlikely	NA	4.8E+0 rem	NA	III	NA	NOT REQUIRED	NONE IDENTIFIED
707-5-7	Unlikely	NA	1.2E+0 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-USQD-2	Unlikely	NA	4.8E+0 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-8	Unlikely	NA	1.2E+0rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-2-7	Unlikely	Extremely Unlikely	1.2E+1 rem	1.2E+0 rem	II	IV	PREVENTIVE: Drum Vent MITIGATIVE: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	NOT REQUIRED
707-2-7A	Unlikely	Extremely Unlikely	1.7E+1 rem	1.7E+0 rem	II	IV	PREVENTIVE: Drum Vent MITIGATIVE: Confinement [(One tested stage) exhaust HEPA filtration or static LPF]	NOT REQUIRED
707-3-11	Unlikely	Extremely Unlikely	1.2E+1 rem	1.2E+1 rem	II	III	PREVENTIVE: Drum Vent	NONE IDENTIFIED
707-3-11A	Unlikely	Extremely Unlikely	1.7E+1 rem	1.7E+1 rem	II	III	PREVENTIVE: Drum Vent	NONE IDENTIFIED

6.2.4 Inadvertent Nuclear Criticalities

The hazard analysis process identified scenarios involving inadvertent nuclear criticalities that resulted in releases of intense gamma and neutron radiation and radioactive fission product materials. The dose from a criticality event is from a prompt dose (also referred to as shine) and a plume dose. The prompt dose is controlled as it passes through air, concrete, or other obstructions. The plume dose is comprised of contributions from particulates and noble gases. The particulate component of the plume dose can be controlled by HEPA filtration and the building LPF. The noble gas component of the plume dose is unaffected by HEPA filtration or the building LPF. Depending upon the type of material involved and the presence of water or oils, the consequences associated with a criticality event differ. Water and/or oil serve as a reflector and moderator reducing the quantity of material required for a criticality and increases the number of fissions.

This section presents analyses of the bounding scenario that addresses a possible criticality scenario within the Building 707 Complex:

- CRITICALITY -- OIL MODERATED METAL (707-D&D-13)

6.2.4.1 CRITICALITY -- OIL MODERATED METAL (707-D&D-13)

This scenario involves the release of intense gamma and neutron radiation and radioactive material from an inadvertent nuclear criticality involving a glovebox containing plutonium metal material suspended in oils recovered from machining equipment. Relevant details, assumptions, and parameters of the scenario are discussed in the following paragraphs and summarized in Table 6.2.4-1A.

Scenario Description

This scenario is postulated to occur because of an oil moderated criticality event involving plutonium metal fines suspended in recovered machining oils in a glovebox. The dominant initiator for this scenario is multiple material and handling errors resulting in a failure to meet the glovebox CSOLs.

Activities

An oil moderated criticality could be initiated by Radioactive Waste Generation and Handling activities.

Assumptions

In addition to the generic assumptions listed at the beginning of Section 6.2, the following additional assumptions were also applied to this accident scenario:

- Using RADDOSE (Ref. 6-11), the scenario was modeled as an oxide-coated metal, single spike criticality. This modeling approach was chosen since little data exists regarding the fission yield of an oil-moderated criticality and was considered appropriately conservative.
- The number of fissions for an oil-moderated criticality is assumed to be $3.0\text{E}+17$ fissions.
- The material is assumed to have the properties of standard WG Pu.

Material At Risk (MAR)

The mass of material is not a factor in an oxide-coated metal criticality. The input variable for this scenario is expressed as the fission yield, $3.0\text{E}+17$ fissions.

Accident Frequency

Without crediting preventive controls, the frequency of an inadvertent nuclear criticality involving a solution is *ANTICIPATED*, based on SARAH.

Accident Consequences and Risk

Without crediting mitigative controls, the dose consequence to the Public is *LOW* ($8.3\text{E}-4$ rem) and the dose consequence to the Worker is *LOW* ($1.8\text{E}+0$ rem). These consequences, when combined with an *ANTICIPATED* frequency, result in a *CLASS III* risk to both the Public and the Worker. However, since a criticality can result in death or serious injury to the Immediate Worker, a *RISK CLASS I* is assigned to the Immediate Worker for any criticality accident.

TABLE 6.2.4-1A. SUMMARY OF ACCIDENT SCENARIO 6.2.4.1
CRITICALITY – OIL MODERATED METAL (707-D&D-13)

HAZARD/MAR	Criticality involving oil moderated metal Plutonium. MAR = 3.0E+17 fission's.							
ACCIDENT TYPE	Criticality involving oil covered plutonium fines stored in a glovebox.							
DOMINANT INITIATOR	Multiple material and handling errors AND failure to meet CSOLs.							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling Secondary:							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC	Anticipated	NA	Low 8.3E-4 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
WORKER	Anticipated	NA	Low 1.8E+0 rem	NA	III	NA	NOT REQUIRED	CAAS (evacuation notification)
IMMEDIATE WORKER	Anticipated	Unlikely	High	NA	I	I	PREVENTION: Criticality Program (Double Contingency) MITIGATION: CAAS (evacuation notification)	NONE IDENTIFIED

Control Set

The preventive control credited to reduce the risk to the Immediate Worker is the **Criticality Control Program**. The Criticality Control Program ensures that appropriate double-contingency requirements are met for every process involving fissionable material, to ensure that sufficient controls are in place such that at least two unlikely, independent, and concurrent changes in process conditions must occur before a criticality accident is possible. Application of the double-contingency requirements as defined in the Criticality Control Program is qualitatively determined to reduce the frequency of this event for the Worker from *ANTICIPATED* to *UNLIKELY*.

One mitigative control credited to reduce the risk to the Immediate Worker is **Criticality Accident Alarm System (CAAS evacuation caused by an emergency response)**. This control reduces the dose consequence to the Immediate Worker.

The evacuation of Facility Personnel (i.e., the Immediate Worker) will be initiated by notification via the CAAS alarms. Upon detection of a criticality excursion, the CAAS notifies the Immediate Worker of a need for immediate evacuation, thereby limiting the time of

exposure. It is estimated that the notification sequence will enable the Immediate Worker to evacuate the area within an hour.

Defense In Depth

There are no identified, nor required, defense in depth controls for this scenario for the Immediate Worker. However, for the Worker, **CAAS (evacuation notification)** is credited for evacuating the 12-Rad Boundary and for alerting Workers, outside of the 12-Rad Boundary, of the criticality accident.

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Broadness

This criticality scenario bounds the scenarios presented in the table below.

**TABLE 6.2.4-1B. ACCIDENTS BOUNDED BY SCENARIO 6.2.4.1
CRITICALITY – OIL MODERATED METAL (707-D&D-13)**

HAZARD/MAR	707-2-21 Criticality Dry Metal 1.0E+17 fissions							
	707-2-22 Criticality Water Moderated Metal 1.0E+17 fissions							
ACCIDENT TYPE	Criticality							
DOMINANT INITIATOR	Closure activities.							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling Secondary: Hazardous Material Handling							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention	With Prevention &	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC								
707-2-21	Anticipated	NA	7.8E-6 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-2-22	Anticipated	NA	1.8E-6 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
WORKER								
707-2-21	Anticipated	NA	5.7E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-2-22	Anticipated	NA	5.7E-1 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
IMMEDIATE WORKER								
707-2-21	Anticipated	Unlikely	High	NA	I	II	PREVENTION: Criticality Program (Double Contingency) MITIGATION: CAAS (evacuation notification)	NONE IDENTIFIED
707-2-22	Anticipated	Unlikely	High	NA	I	II	PREVENTION: Criticality Program (Double Contingency) MITIGATION: CAAS (evacuation notification)	NONE IDENTIFIED

6.2.5 Natural Phenomena and External Events

In addition to the analysis of operational hazards and accidents, an analysis of accidents resulting from Natural Phenomena Hazards (NPHs) and EEs was also conducted for this DBIO. The evaluation-basis events analyzed relate to the facility's designed capability and the analysis, based on definable and defensible MARs. The following NPH scenario was evaluated:

- NATURAL PHENOMENA HAZARD – EARTHQUAKE (707-6-54)

6.2.5.1 NATURAL PHENOMENA HAZARD – EARTHQUAKE (707-6-54)

This scenario involves the release of radioactive material caused by structural damage to the Building 707 Complex from a seismic event. Relevant details, assumptions, and parameters of the scenario are discussed in the following paragraphs and summarized in Table 6.2.5-1.

Scenario Description

This scenario is postulated to occur because of a seismic-induced failure of Building 707. The seismic evaluation documented in RET-011-98, *Building 707 Seismic Upgrade Evaluation* (Ref. 6-17), concluded that Building 707 would collapse at a surface acceleration of 0.10 g. In addition, although this evaluation concludes that Building 707A is seismically qualified to withstand earthquakes up to 0.424 g, it also concluded that there is a 67% probability that, if Building 707 were to collapse, it would cause 25% to 75% damage to Building 707A.

For this scenario, the earthquake is assumed to impact all support systems (e.g., electrical power, ventilation, HEPA filtration, and fire suppression) and cause damage to internal components (e.g., piping, ducting, gloveboxes, drums, and containers). Therefore, active mitigative controls that could reduce the risk after the accident are considered unavailable.

Although the earthquake is assumed to result in structural damage to Building 707/707A, subsequent events such as fires, explosions, or criticalities are not modeled in this scenario but are discussed semi-quantitatively at the end of this section.

Activities

There are no primary activities identified to initiate this accident. However, this accident would impact all activities that are taking place in the facility at the time of the event.

Assumptions

In addition to the generic assumptions listed at the beginning of Section 6.2, the following additional assumptions were also applied to this accident scenario:

- Using RADIDOSE (Ref. 6-11), the scenario was modeled as a spill involving the entire dispersible inventory in Buildings 707 and 707A, assumed to consist of confined materials

(in closed containers), oxides, and unconfined, non-combustible surfaces (as fixed and loose surface contamination).

- Release duration is assumed to be 10 minutes (per the default value in SARAH used to bound the analysis results).
- No other subsequent effects from fire, explosion, or criticalities are considered in this scenario. (These are discussed at the end of this subsection.)
- The MAR is assumed to be comprised of the entire dispersible inventory in Buildings 707 and 707A.
- DR is 100% for powders and loose surface contamination and 10% for material in closed containers and fixed surface contamination.

Material At Risk (MAR)

The dispersible inventory in Buildings 707 and 707A is 68,000 g based on the following inventories assumed for this scenario (Note: The MAR contribution from Building 778 is considered negligible and is not included):

- Loose surface contamination: 16,000 g.
- Fixed surface contamination: 37,000 g.
- Exposed oxides: 1,000 g.
- Contained TRU: 14,000 g.

Accident Frequency

The frequency of a seismic event capable of causing structural damage to the Building 707 Complex is *UNLIKELY*, based on RET-011-98, *Building 707 Seismic Upgrade Evaluation* (Ref. 6-17).

Accident Consequences and Risk

Without crediting mitigative controls, the consequence to the Public is *MODERATE* and to the Worker is *HIGH* (6.0E-1 rem and 6.0E+1 rem, respectively). These consequences, when combined with an *UNLIKELY* frequency, result in a *CLASS II* risk to the Public and a *CLASS I* to the Worker.

TABLE 6.2.5-1A. SUMMARY OF ACCIDENT SCENARIO 6.2.5.1
NATURAL PHENOMENA HAZARD – EARTHQUAKE (707-6-54)

HAZARD/MAR	Structural damage to Building 707/707A caused by a seismic event MAR = 68,000 g of Pu equivalence (based on the entire dispersible inventory in Buildings 707 and 707A): 14,000 g of contained TRU, 1,000 g of exposed oxide, 16,000 g of loose surface contamination, 37,000 g of fixed surface contamination Effective MAR = 14,000 g of confined materials, 1,000 g of powder, 19,700 g (16,000 + 0.1(37,000)) of unconfined non-combustible surfaces							
ACCIDENT TYPE	Natural Phenomena Hazard							
DOMINANT INITIATOR	Seismic event with 0.1 g magnitude							
VULNERABLE DBIO ACTIVITIES	Primary: N/A Secondary: N/A							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC	Unlikely	Unlikely*	Moderate 6.0E-1 rem	NA	II	NA	NONE IDENTIFIED	NONE IDENTIFIED
WORKER	Unlikely	Unlikely*	High 6.0E+1 rem	NA	I	NA	NONE IDENTIFIED	NONE IDENTIFIED

* No preventive or mitigative controls credited to reduce the frequency or consequence. Additional dose (consequence from other scenarios such as fire or criticality) can be added to this scenario to form additional scenarios.

Control Set

No preventive or mitigative controls can be credited to reduce the risk to the Public or the Worker; as such, this scenario will be further discussed in Section 6.5.

Defense In Depth

There are no defense-in-depth controls identified for prevention or mitigation for the Public and the Worker.

Broadness

This bounding scenario encompasses additional events.

TABLE 6.2.5-1B. ACCIDENTS BOUNDED BY SCENARIO 6.2.5.1
NATURAL PHENOMENA HAZARD – EARTHQUAKE (707-6-54)

HAZARD/MAR	707-6-59 Natural Phenomena Hazard – High Wind and Tornado 1,000g (1 10-gal drum)							
	707-D&D-14 Crane Load Impact 6,050g (30 drums @200g)							
	707-6-51 External Event – Aircraft Crash Not analyzed -- considered equivalent to an Earthquake with a Fire (see discussion below)							
	707-6-53 External Event – Station Blackout 17,000g (Module Holdup) and 1,000g Oxide in an 8801 container							
	17,000g (Module Holdup) and 1,000g Oxide in an 8801 container							
ACCIDENT TYPE	Fire							
DOMINANT INITIATOR	NA.							
VULNERABLE DBIO ACTIVITIES	Primary: Radioactive Waste Generation and Handling and Decommissioning-Decontaminate, Dismantle, and Demolish Secondary: Hazardous Material Handling							
RECEPTOR	SCENARIO FREQUENCY		CONSEQUENCES		RISK CLASS		CONTROLS	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Specific Credited Controls	Defense-In-Depth Controls
PUBLIC								
707-6-59	Unlikely	NA	7.4E-4 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-14	Unlikely	NA	2.1E-02 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-6-53	Anticipated	NA	2.3E-03 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
WORKER								
707-6-59	Unlikely	NA	9.0E-02 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-D&D-14	Unlikely	NA	2.1E+0 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED
707-6-53	Anticipated	NA	9.9E-01 rem	NA	III	NA	NOT REQUIRED	NOT REQUIRED

707-6-51, EE – Aircraft Crash, was considered bounded by the earthquake scenarios in that the frequency of occurrence of an Aircraft Crash is *EXTREMELY UNLIKELY*, and the resulting damage to the facility is postulated to be the same or similar as that for the earthquake. As such, the consequences were not analyzed.

The following discussion introduces additional attributes and considerations to demonstrate that this scenario adequately encompasses this additional PHA event.

This scenario was postulated to result from a 0.1-g seismic event that impacts Building 707. Based on the estimated return periods for these events, a 0.1-g seismic event is *UNLIKELY*.

Seismically induced events (such as fires, explosions, and criticality) may accompany and/or follow the seismic event. The seismically induced events discussed in the following paragraphs are conservatively modeled to occur during and following the earthquake, with no credit for the collapse of the structure (that could block the release of much of the assumed MAR).

Earthquake With Fire – In conjunction with a seismic event, there is a conditional probability that a fire will occur, although at a reduced frequency. In the past, the PHA identified two seismic events followed by fire. The bounding dose from these events is postulated to result from the earthquake scenario described above and a small glovebox fire. The small glovebox fire is postulated to involve 1,000 g of plutonium oxide as presented in Table 6.2.1-1B. The consequences, when combined with an estimated *UNLIKELY* frequency, results in *CLASS II* risk to the Public, and *CLASS I* risk to the Worker.

Earthquake With Criticality – In conjunction with a seismic event, there is a conditional probability that a criticality will occur, although at a reduced frequency. If the earthquake occurred concurrently with the oil moderated criticality scenario discussed in this DBIO (707-D&D-13), the consequences to the Public would be *MODERATE* and to the Worker would be *HIGH*. The consequences, when combined with an estimated *EXTREMELY UNLIKELY* frequency, results in *CLASS III* risk to the Public, and *CLASS II* risk to the Worker.

6.2.6 Summary of Accident Analysis

A summary of the frequencies, consequences, and risk classes for the preceding accident scenarios are presented in Table 6.2.6-1 below.

TABLE 6.2.6-1. SUMMARY OF ACCIDENT ANALYSIS

Scenario Case	Scenario Frequency		Public Consequences		Public Risk Class		Worker Consequences		Worker Risk Class	
	Without Prevention	With Prevention	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation	Without Mitigation	With Mitigation	Without Prevention or Mitigation	With Prevention & Mitigation
SMALL FIRE, CONTAINER (707-D&D-1)										
Anticipated	Anticipated		1.3E-1 rem	--	III	--	1.3E+1 rem	1.3E+0 rem	I	III
MEDIUM FIRE, CONTAINERS (707-D&D-3)										
Anticipated	Unlikely		1.4E-1 rem	--	III	--	1.4E+1 rem	1.4E+0 rem	I	III
LARGE FIRE, CONTAINERS (707-D&D-5)										
Anticipated	Extremely Unlikely		2.3E-1 rem	--	III	--	2.3E+1 rem	2.3E+0 rem	I	III
MAJOR FIRE, MAJOR POOL FIRE (707-D&D-7a)										
Unlikely	Extremely Unlikely		1.5E+0 rem		II	III	1.5E+2 rem	1.5E+1 rem	I	III
SPILL, CONTAINER IMPACT INSIDE BUILDING (707-6-13)										
Anticipated	Anticipated		1.4E-1 rem	--	III	--	1.4E+1 rem	1.4E+0 rem	I	III
EXPLOSION, MODULE VAPOR-CLOUD (707-D&D-9)										
Unlikely	Extremely Unlikely		1.7E-1 rem	--	III	--	1.7E+1 rem	1.7E+0 rem	II	VI
CRITICALITY, OIL MODERATED METAL (707-D&D-13)										
Anticipated	Unlikely		8.3E-4 rem	-	III	-	1.8E+0 rem	-	III	-
Anticipated (Immediate Worker)	-		-	-	-	-	High	High	I	I
NATURAL PHENOMENA HAZARD, EARTHQUAKE (707-6-54)										
Unlikely	Unlikely		6.2E-1 rem	-	II	-	6.0E+1 rem	-	I	-

6.3 HIGH-RISK SCENARIOS

The high-risk scenarios identified in the accident analyses include scenario 6.2.4.1, CRITICALITY – OIL MODERATED METAL (707-D&D-13), scenario 6.2.5.1, NATURAL PHENOMENA HAZARD – EARTHQUAKE (707-6-54), and AIRCRAFT CRASH (707-6-51). As identified in these scenarios, no preventive or mitigative controls can be credited to reduce the risk to the receptor of interest. The Earthquake With Fire scenario bounds the EE – AIRCRAFT CRASH scenario, in that the results will be the same or similar and that no controls can be credited to reduce the risk.

The only practical way to minimize the risk of these accidents is to remove the MAR from the facility and dismantle the facility (D&D). Since this is the current mission of the facility, the risk of these scenarios should be accepted, and decommissioning and demolition of Building 707 should continue.

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